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COMPRESSED AIR MAGAZINE

DEVOTED TO THE USEFUL APPLICATIONS OF COMPRESSED AIR

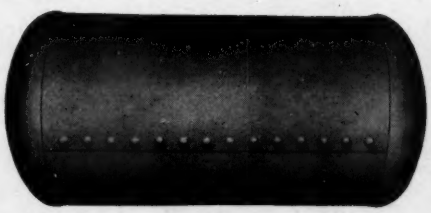
Vol. xxiv FEBRUARY, 1919 No. 2

Scaife Copper-Brazed Tanks

The Ideal Containers

For Compressed Air and Gas

These cuts are from actual photographs of a Scaife Copper-Brazed Tank purposely tested to destruction. Notice the distorted shape of the burst tank and the splendid condition of all the copper-brazed joints, proving conclusively that they are stronger than any other part of the tank.



This tank was 12″ diamater, shell 7-64″, heads 3-16″; tensile strength of the steel, about 58,000 lbs. The tear in the shell occurred when the applied pressure reached 1,035 lbs. per sq. in.; all the brazed joints remaining intact. Similar tests have been frequently made by entirely disinterested tank experts with the same results as in this case.

Hundreds of our brazed tanks made over twenty years ago are still in service. The copper coating around the seams protects these parts from corrosion; so that they retain their original high efficiency after the material in other parts of the tank, as a result of long usage, may have become badly rusted. **MADE ONLY BY**

WM. B. SCAIFE & SONS COMPANY

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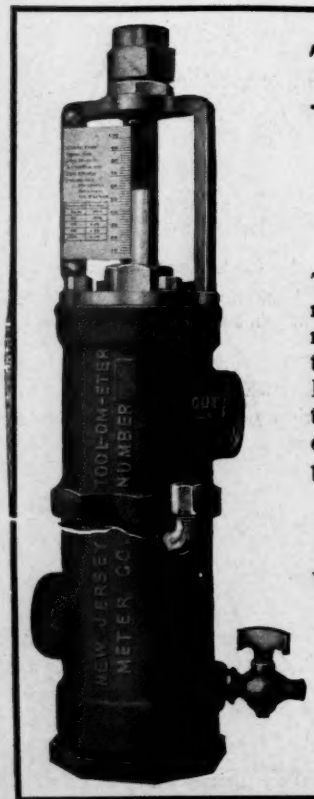

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Vol. xxiv FEBRUARY, 1919 No. 2

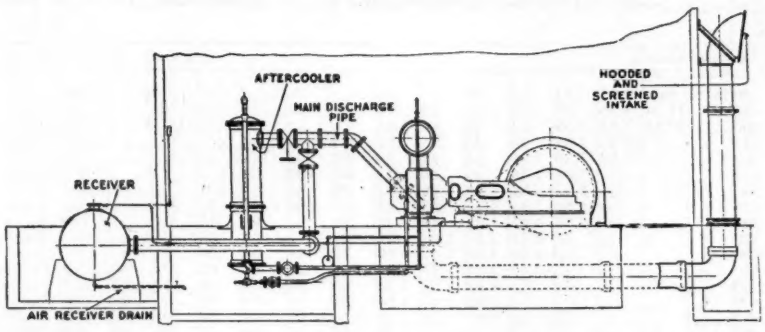


FIG. I. PROPER ARRANGEMENT OF AIR INTAKE AND PIPING

COMPRESSING AIR EFFICIENTLY

By Charles A. Hirschberg

Economical and efficient operation of air compressors demands regular inspection. The compressor as a whole should be inspected at least once a month, making necessary adjustments, such as taking up of packing glands and replacement of worn parts.

Examine air valves, which should present an oily surface free from carbon. Also examine ports and passages for carbon or other obstructions. Carbon desposit on valves prevents their seating properly, causes leakage and results in reduced compressor capacity and low efficiency. Obstructions in air passages reduce their area and cause loss in friction. Carbon deposit in combination with high temperature due to improper cylinder cooling, sticking of valves or insufficient lubrication may result in explosions, if allowed to persist. Remove any carbon deposit.

PACKING

Use of packings is often misunderstood. Drawing up too tightly will cause heating, and scoring of the piston rod. This means higher temperatures and increased mechanical friction, with transmitting of increased temperature to the air in the cylinder, which will cause trouble with moisture, lower the air density and thereby reduce the output.

In placing the packing in the stuffing box, put the rings in so that the joints of the several rings stagger. Fill the box without crowding and with new packng force in slightly with the gland until the compressor warms up; then draw up just enough to prevent blowing. Crowding the packing will squeeze out the lubricant it contains, causing the packing to become hard and unyielding.

If upon examination packing is found hard, it may be revived by removing, loosening up, and working in a mixture of graphite and grease.

An asbestos sheet packing is generally used between cylinder heads and cylinders. If for any reason it becomes necessary to remove a head, care should be exercised not to injure this head gasket. If necessary to replace it,

be sure to use material of the same thickness as the original, so as to maintain the clearance established by the builder.

INLET AIR

Do not have the air intake open to the engine room. Carry it outdoors and extend upward a sufficient height, with hood and screen, to prevent foreign substances from being drawn in and to insure cool intake air.

Figure 1 shows an ideal method of handling the air intake.

Take the air into the compressor as cool as possible is the rule without any exception. Cooling the intake air is a direct saving of power by reducing the volume to be com-

Delivery in Cu. Ft. of Compressed Air per Min.	Equiv. Delivery in Cu. Ft. of Free Air per Min.	Size of Pipe, Inches: 1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	16
		Loss of Pressure, in Pounds, by Friction in 1000 Feet Lengths of Pipe																	
At 60 Pounds Gauge																			
9.84	50	18.24	5.06	1.95	.42	.13	.05												
14.73	75		11.34	4.33	.95	.29	.11	.05											
19.64	100		20.16	7.79	1.69	.52	.19	.08	.04										
24.60	125			12.23	2.65	.81	.30	.13	.07	.03									
29.45	150			17.53	3.80	1.16	.44	.19	.09	.05	.03								
34.44	175				5.17	1.58	.59	.26	.13	.07	.04	.01							
39.35	200				6.77	2.09	.78	.36	.17	.09	.06	.02	.01						
49.20	250				10.61	3.24	1.22	.55	.27	.15	.08	.03	.01						
58.90	300				15.20	4.65	1.78	.78	.38	.21	.12	.05	.02	.01					
68.6	350					6.31	2.37	1.07	.53	.29	.17	.06	.03	.01					
78.6	400					8.28	3.11	1.40	.69	.39	.22	.08	.04	.01					
88.4	450					10.47	3.94	1.77	.88	.48	.28	.11	.05	.02	.01				
98.4	500						4.88	2.20	1.08	.60	.34	.14	.06	.03	.01				
118.1	600						7.03	3.17	1.56	.87	.49	19	.09	.04	.02	.01			
137.5	700						9.52	4.29	2.12	1.17	.67	.27	.12	.06	.03	.02			
156.6	800							5.57	2.75	1.52	.87	.34	.15	.08	.04	.03	.01		
176.5	900							7.08	3.49	1.94	1.17	.43	.19	.09	.05	.03	.01		
196.4	1000							8.77	4.33	2.40	1.37	.54	.24	.12	.06	.04	.02	.01	
294.5	1500								9.73	5.39	3.08	1.20	.55	.27	.15	.09	.03	.01	
393.7	2000									9.65	5.51	2.16	.98	.41	.27	.16	.06	.03	.01
492	2500										8.61	3.36	1.53	.77	.42	.25	.09	.04	.02
589	3000											4.82	2.19	1.11	.61	.36	.14	.06	.03
686	3500											6.54	2.97	1.50	.83	.48	.19	.09	.04
786	4000												3.91	1.98	1.08	.63	.25	.11	.05
884	4500												4.94	2.51	1.36	.79	.32	.15	.07
984	5000												6.19	3.10	1.69	.99	.39	.18	.09
At 80 Pounds Gauge																			
7.74	50	14.31	3.96	1.53	.33	.10	.03	.01											
11.3	75		8.46	3.26	.71	.21	.08	.03	.01										
15.2	100		15.31	5.92	1.28	.39	.14	.06	.03	.02	.01								
19.4	125			9.64	2.09	.64	.24	.11	.05	.03	.01								
23.2	150			13.79	2.99	.91	.34	.15	.07	.04	.02	.01							
27.2	175				4.09	1.25	.47	.21	.10	.06	.03	.01							
31.0	200				5.34	1.63	.61	.27	.13	.07	.04	.01							
38.7	250				8.32	2.54	.96	.43	.21	.12	.07	.02	.01						
46.5	300				12.01	3.67	1.38	.62	.30	.17	.09	.03	.01						
54.2	350					4.99	1.88	.84	.41	.23	.13	.05	.02	.01					
62.0	400					6.53	2.45	1.11	.54	.30	.17	.06	.03	.01					
69.7	450					8.25	3.13	1.40	.69	.38	.22	.08	.04	.01					
77.4	500					10.81	3.83	1.73	.85	.47	.27	.10	.05	.02	.01				
92.9	600						5.61	2.46	1.22	.68	.39	.15	.06	.03	.02	.01			
108.2	700						7.46	3.37	1.66	.92	.53	.20	.09	.04	.02	.01			
124.0	800						9.86	4.42	2.18	1.19	.69	.27	.12	.06	.03	.02	.01		
139.5	900							5.61	2.77	1.54	.88	.34	.15	.08	.04	.02	.01		
152	1000							6.64	3.29	1.82	1.04	.40	.18	.09	.05	.03	.01		
232	1500							15.41	7.62	4.24	2.43	.95	.43	.22	.12	.06	.02	.01	
310	2000								13.62	7.58	4.32	1.69	.77	.39	.21	.12	.04	.02	.01
387	2500									11.79	6.88	2.64	1.19	.60	.33	.19	.07	.03	.01
465	3000										9.72	3.79	1.73	.87	.48	.28	.11	.05	.02
542	3500										13.25	5.27	2.35	1.19	.65	.37	.15	.06	.03
620	4000											6.78	3.07	1.55	.85	.49	.19	.09	.04
697	4500											8.54	3.89	1.97	1.08	.66	.25	.11	.05
774	5000											10.55	4.79	2.46	1.33	.77	.30	.14	.07

FIG. 2. LOSS OF AIR PRESSURE IN PIPE TRANSMISSION

pressed. Also the capacity of the air to hold moisture rapidly falls off as its temperature is reduced.

TRANSMISSION PIPING

Pipe lines should be of ample size, as small transmission lines mean excessive loss of pressure due to friction. Large pipe lines are especially desirable where the pipes are long or the supply has to meet the demands of a great many devices. Reduced pressure due to friction means inefficient operation of tools.

The accompanying chart, Fig. 2, covering "Loss in pressure due to friction in pipe lines" will serve to indicate the need for having the pipe line amply large. Take, for example, the following case:

Delivery in Cu. Ft. of Compressed Air per Min.	Equiv. Delivery in Cu. Ft. of Free Air per Min.	Size of Pipe, Inches																
		1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	16
		Loss of Pressure, in Pounds, by Friction in 1000 Feet Lengths of Pipe																
At 100 Pounds Gauge																		
6.41	50	11.89	3.29	1.28	.27	.08	.03	.01										
9.61	75		7.42	2.87	.62	.19	.07	.03	.01									
12 81	100		13.20	5.11	1.15	.34	.12	.05	.02	.01								
15.81	125			7.75	1.68	.52	.19	.08	.04	.02	.01							
19.22	150			11.42	2.48	.76	.29	.13	.06	.03	.02	.01						
22.39	175				3.36	1.03	.39	.17	.09	.04	.03	.01						
25.62	200				4.43	1.36	.51	.23	.12	.06	.04	.02	.01					
31.62	250				6.72	2.06	.77	.35	.17	.09	.05	.02	.01					
38.44	300				9.95	3.04	1.14	.51	.25	.14	.08	.03	.01					
44.78	350				13.41	4.11	1.54	.69	.34	.19	.11	.04	.02	.01				
51.24	400					5.40	2.06	.92	.45	.25	.15	.05	.03	.01				
57.65	450					6.85	2.57	1.16	.57	.32	.18	.07	.03	.02	.01			
63.24	500					8.21	3.08	1.39	.68	.38	.22	.08	.04	.02	.01			
76.88	600					12.21	4.58	2.14	1.03	.57	.33	.12	.05	.03	.02	.01		
89.56	700						6.19	2.79	1.38	.77	.44	.17	.07	.04	.02	.01		
102.5	800						8.13	3.67	1.81	1.00	.57	.22	.10	.05	.03	.02	.01	
115.3	900						10.23	4.64	2.29	1.27	.76	.28	.13	.06	.04	.02	.01	
126.5	1000						12.39	5.00	2.76	1.23	.88	.34	.16	.08	.04	.03	.01	
192.2	1500							12.81	6.68	3.51	2.03	.78	.36	.18	.09	.05	.02	.01
256.2	2000								11.35	6.61	3 62	1.41	.67	.33	.18	.10	.04	.02 .01
316.2	2500									9.50	5.51	2.14	.97	.49	.27	.16	.06	.03 .01
384.4	3000									14.04	8.11	3.16	1.44	.76	.39	.23	.19	.04 .02
447.8	3500										10.95	4.26	1.93	.98	.53	.31	.12	.05 .03
512.4	4000										14.48	5.59	2.55	1.30	.72	.41	.16	.07 .04
576.5	4500											7.04	3.22	1.84	.89	.52	.21	.09 .05
632.4	5000											8.51	3.88	1.93	1.07	.63	.25	.11 .08
At 125 Pounds Gauge																		
5.26	50	9.88	2.70	1.05	.23	.07	.03	.01										
7.89	75	22.20	6.07	2.37	.51	.16	.06	.03	.01									
10.51	100	39.50	10.82	4.22	.91	.28	.10	.05	.02	.01								
13.15	125		16.88	6.58	1.42	.43	.16	.07	.04	.02	.01							
15.79	150		24.33	9.47	2.04	.63	.23	.11	.05	.03	.02	.01						
18.41	175		33.05	12.90	2.78	.85	.32	.14	.07	.04	.02	.01						
21.05	200			16.84	3.63	1.11	.42	.19	.09	.05	.03	.01						
26.30	250			26.30	5.68	1.73	.65	.29	.15	.08	.05	.02	.01					
31.58	300			37.90	8.18	2.51	.94	.42	.21	.12	.07	.03	.01					
36.81	350				11.08	3.39	1.27	.58	.28	.16	.09	.04	.02	.01				
42.10	400				14.51	4.44	1.67	.75	.37	.21	.12	.05	.02	.01				
47.30	450				18.38	5.61	2.11	.95	.47	.26	.15	.06	.03	.01	.01			
52.60	500				22.68	6.95	2.61	1.18	.58	.32	.18	.07	.03	.02	.01			
63.20	600					10.00	3.76	1.69	.84	.46	.27	.10	.05	.02	.01	.01		
73.70	700					13.60	5.11	2.31	1.14	.63	.36	.14	.06	.03	.02	.01		
84.20	800					17.80	6.68	3.01	1.49	.83	.47	.18	.08	.04	.02	.01	.01	
94.70	900						8.45	3.81	1.88	1.04	.60	.23	.11	.05	.03	.02	.01	
105.1	1000						10.42	4.71	2.32	1.29	.74	.29	.13	.07	.04	.02	.01	
157.9	1500						23.48	10.59	5.23	2.90	1.65	.64	.29	.15	.08	.05	.02	.01
210.5	2000							18.81	9.30	5.15	2.94	1.15	.52	.26	.15	.08	.03	.02 .01
263.0	2500							29.40	14.52	8.05	4.60	1.80	.82	.41	.23	.13	.05	.02 .01
315.8	3000								20.90	11.59	6.63	2.59	1.18	.60	.33	.19	.07	.03 .02
368.1	3500								28.51	15.78	9.01	3.53	1.61	.81	.45	.26	.10	.04 .02
422.0	4000									20.61	11.80	4.61	2.19	1.06	.58	.34	.13	.06 .03
473.0	4500									26.10	14.90	5.83	2.65	1.34	.73	.43	.17	.08 .04
526.0	5000									32.20	18.45	7.20	3.27	1.65	.90	.53	.21	.10 .05

FIG. 2. CONTINUED

Receiver Gauge Pressure	Diameter of Orifice												
Pounds	1/16 inch	1/8 inch	3/16 inch	1/4 inch	5/16 inch	3/8 inch	1/2 inch	5/8 inch	3/4 inch	7/8 inch	1 inch	1 1/4 inch	1 1/2 inch
	Discharge in Cubic Feet of Free Air per Minute												
2	.038	.153	.647	2.435	9.74	21.95	39.	61.	87.60	119.50	156.	242.	350.
5	.0597	.242	.965	3.86	15.40	34.60	61.60	96.50	133.	189.	247.	384.	550.
10	.0842	.342	.136	5.45	21.8	49.	87.	136	196.	267.	350.	543.	780.
15	.103	.418	1.67	6.65	26.70	60.	107.	167	240	326.	427.	665.	960.
20	.119	.485	1.93	7.7	30.8	69.	123.	193	277	378.	494.	770.	.....
25	.133	.54	2.16	8.6	34.5	77	138.	216	310	422.	550	860.	.....
30	.156	.632	2.52	10.	40.	90.	161.	252.	362.	493	645.	1000.	.....
35	.173	.71	2.80	11.2	44.7	100.	179.	280.	400	550.	715.	.....	.....
40	.19	.77	3.07	12.27	49.09	110.45	196.35	306.80	441 79	601.32	785.40	.....	.....
45	.208	.843	3.36	13.4	53.8	121.	215.	336	482	658.	860.	.....	.....
50	225	.914	3.64	14 50	58.2	130	232	364.	522	710.	930.	.....	.....
60	.26	1.05	4.2	16 8	67.	151	268	420	604.	622	.....	.....	.....
70	.295	1.19	4.76	19	76.	171	304.	476.	685.	930	.....	.....	.....
80	.33	1.33	5.32	21.2	85	191	340.	532.	765.	1004.	.....	.....	.....
90	.364	1.47	5.87	23.50	94	211	376	587.	843.	.....	.....	.....	.....
100	.40	1.61	6 45	25.8	103.	231	412.	645	925.	.....	.....	.....	.....
125	.486	1.97	7.85	31.4	125	282.	502	785.	.....	.....	.....	.....	.....

FIG. 3. DISCHARGE OF AIR FROM ROUND HOLE TO ATMOSPHERE

The loss in pressure in transmitting 50 cu. ft. of free air per minute at 100 lb. pressure through 1000 ft. of 1-in. ppie is 11.89 lb., and only 0.27 lb. in transmitting the same volume of air the same distance through a 2-in. pipe.

Air lines should receive monthly inspection for leaks, which cost money and waste valuable compressor capacity. Assuming that 1 cu. ft. of air per min. at 100 lb. pressure costs $5 a year, this cost being computed from an estimated cost for electricity at 1c per kw.-hr., interest and depreciation at 10 per cent. and a year as 300 8-hr. days, the following tabulation demonstrates the economy of regular pipe line inspections:

Diam. of hole, in.	Amount of Leak in cu. ft. free air per min.	Cost per year
1/16	6.45	$32
1/32	1.61	8
1/64	.40	2

Further calculations of possible loss through leaks may be quickly made by applying the above constant to the various discharge volumes shown in Fig. 3.

It is always advisable to provide numerous outlets in the transmission line. This will save future reconstruction and make it possible to use comparatively shorter lengths of hose. Where a number of supply lines radiate from the main line, it is well to provide a gate valve for cutting out any of these lines when they are to be idle for any considerable period of time.

Several methods are used of detecting air leaks: By the use of a lighted candle at all joints and connections; by swabbing soapy water around the joints, or by following the practice of one Illinois manufacturer, who, at regular intervals, puts essence of peppermint into the air system and then has all the pipes inspected. Leaks are revealed by the odor.

Pipe lines may be tested for loss of pressure

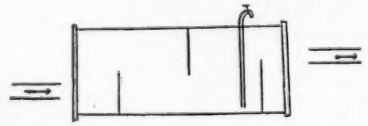


FIG. 4

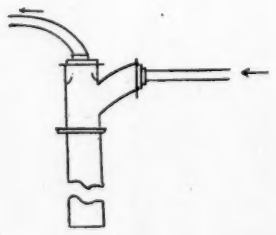


FIG. 5

due to friction in transmission or to leakage by placing an air gage at the point of use of the air and comparing its reading with that of the gage on the air receiver. The remedies are increasing the size of the air line and eliminating of leaks.

REMOVING MOISTURE

All air contains moisture. When compressed the moisture becomes more evident, as in the compressed state there is more water in the air than it can contain. The excess moisture is deposited almost immediately as the air travels to the receiver; part of it travels with the air through the transmission lines, being gradually deposited and draining to low spots in the pipes, reducing the available area. Some of the moisture will find its way into the ports and exhaust passages of the machinery using the air, resulting in interference with proper operation by freezing at exhaust ports as the air expands to atmosphere.

One of the most effective and cheapest methods for the elimination of moisture from pipe lines is the placing of suitable traps at intervals in the transmission line into which the condensed moisture will precipitate and can be conveniently withdrawn.

A simple moisture trap, in Fig. 4, consists of an enlargement of the air line. It is provided with baffles and blowoff, the baffles having holes or slots drilled in the bottom so that moisture can work through to the blowoff pipe. By reason of the pressure always present in the separator the water can be taken from the top. This trap may be made of wrought or cast-iron pipe with flanged or screwed heads. A good proportion is separator diameter 3 times the air line diameter; 4 to 6 ft. long.

Another effective design is shown in Fig. 5, consisting of a long sweep tee three times the diameter of the pipe with a pocket below to catch the condensed moisture.

Both of these separators may be made locally from standard pipe fittings; also, there are a number of standard built moisture traps which may be purchased from various manufacturers.

Moisture traps should be placed at low points in the air line.

REHEATING COMPRESSED AIR

Reheating the air is a simple process and serves the double purpose of eliminating annoyance due to freezing as a result of the moisture which the air may contain, and at the same time increasing the air volume.

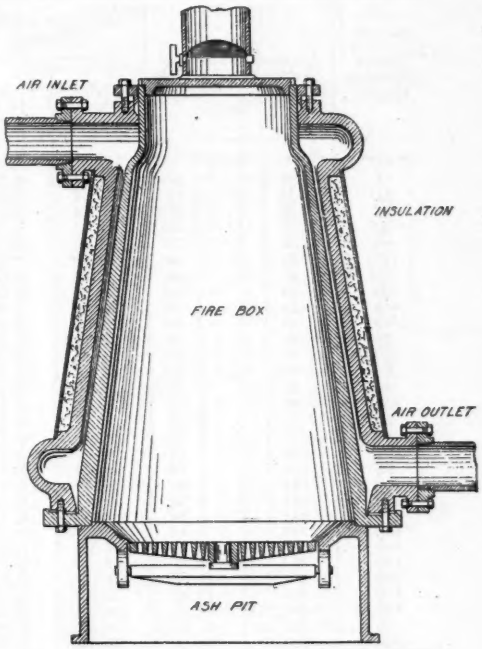


FIG. 6. STANDARD AIR REHEATER

When the warm compressed air leaves the compressor and passes through the receiver and the transmission lines to the point of use, the temperature of the air is considerably reduced. This represents a loss in volume. If the air were used immediately adjacent to the point of production, this loss would not be experienced, but the latter condition seldom, if ever, prevails.

Reheating the compressed air, at the point where it is to be utilized, a temperature of 250 deg. F., which is quite usual, results in expanding it in volume from 30 to 35 per cent., at a cost of about ⅛ of the heat units required to produce the same volume by compression. This approximation is based on the use of effective form of reheater, and the use of the air in the cylinder of the engine immediately after passing from the reheater.

In using the reheater, therefore, it should be placed as closely as possible to the point of use of the air, to prevent loss from radiation of heat after the reheating process.

The reheater may consist of a cast-iron chamber containing a coil of pipe exposed to a fire, or a current of hot gas or steam. Figure 6 shows a cross-section view of one stand-

Gauge Pressure Pounds	Absolute Pressure Pounds	Number of Atmospheres	Isothermal Compression		Adiabatic Compression			
			Mean Effective Pressure	H. P.	Mean Effective Pressure Theoretical	Mean Eff. Pressure plus 15% Friction	H. P. Theoretical	H. P. plus 15% Friction
5	19.7	1.34	4.13	0.018	4.46	5.12	0.019	0.022
10	24.7	1.68	7.57	0.033	8.21	9.44	0.036	0.041
15	29.7	2.02	11.02	0.048	11.46	13.17	0.050	0.057
20	34.7	2.36	12.62	0.055	14.30	16.44	0.062	0.071
25	39.7	2.70	14.68	0.064	16.94	19.47	0.074	0.085
30	44.7	3.04	16.30	0.071	19.32	22.21	0.084	0.096
35	49.7	3.38	17.90	0.078	21.50	24.72	0.094	0.108
40	54.7	3.72	19.28	0.084	23.53	27.05	0.103	0.118
45	59.7	4.06	20.65	0.090	25.40	29.21	0.111	0.127
50	64.7	4.40	21.80	0.095	27.23	31.31	0.119	0.136
55	69.7	4.74	22.95	0.100	28.90	33.23	0.126	0.145
60	74.7	5.08	23.90	0.104	30.53	35.10	0.133	0.153
65	79.7	5.42	24.80	0.108	32.10	36.91	0.140	0.161
70	84.7	5.76	25.70	0.112	33.57	38.59	0.146	0.168
75	89.7	6.10	26.62	0.116	35.00	40.25	0.153	0.175
80	94.7	6.44	27.52	0.120	36.36	41.80	0.159	0.182
85	99.7	6.78	28.21	0.123	37.63	43.27	0.164	0.189
90	104.7	7.12	28.93	0.126	38.89	44.71	0.169	0.195
95	109.7	7.46	29.60	0.129	40.11	46.12	0.175	0.201
100	114.7	7.80	30.30	0.132	41.28	47.46	0.180	0.207
110	124.7	8.48	31.42	0.137	43.56	50.09	0.190	0.218
120	134.7	9.16	32.60	0.142	45.69	52.53	0.199	0.229
130	144.7	9.84	33.75	0.147	47.72	54.87	0.208	0.239
140	154.7	10.52	34.67	0.151	49.64	57.08	0.216	0.249
150	164.7	11.20	35.59	0.155	51.47	59.18	0.224	0.258
160	174.7	11.88	36.30	0.158	53.70	61.80	0.234	0.269
170	184.7	12.56	37.20	0.162	55.60	64.00	0.242	0.278
180	194.7	13.24	38.10	0.166	57.20	65.80	0.249	0.286
190	204.7	13.92	38.80	0.169	58.80	67.70	0.256	0.294
200	214.7	14.60	39.50	0.172	60.40	69.50	0.263	0.303

FIG. 7. SINGLE STAGE COMPRESSION

ard type of air reheater, which requires no explanation.

POWER UTILIZED IN COMPRESSING

Two tables shown in Fig. 7 show the horsepower required for compressing air in single stage and two stage compressors at various gage pressures. All the conditions of the calculations given are explained in the headings.

MECHANICAL EFFICIENCY

Mechanical efficiency of an air compressor is represented by the ratio of the indicated air horsepower to the indicated steam horsepower in the case of a steam-driven machine, and to the brake horsepower in the case of a power-driven machine.

The difference between the two represents excess power required to overcome frictional resistance of the machine, which is largely dependent upon the design, the workmanship and the supervision received when in operation.

Mechanical efficiency of the well designed air compressor ranges between 90 and 95 per cent.

Let us assume a power-driven air compressor of the following size and displacement and determine its mechanical efficiency:

Diameter low-pressure cylinder, 16 in.; diameter high-pressure cylinder, 10 in.; stroke, 14 in.; r.p.m., 165; discharge pressure, gage, 100 lb.; piston displacement, cu. ft. per min., 534.

From brake test it was found that the brake horsepower is 93.

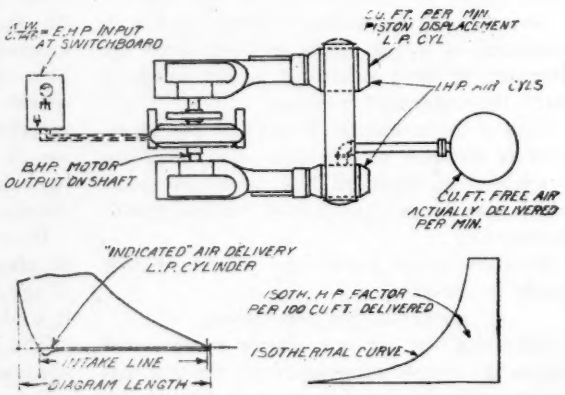

E.H.P. INPUT AT SWITCHBOARD
CU. FT. PER MIN. PISTON DISPLACEMENT L.P. CYL
I.H.P. AIR CYLS
B.H.P. MOTOR OUTPUT ON SHAFT
CU. FT. FREE AIR ACTUALLY DELIVERED PER MIN.
"INDICATED" AIR DELIVERY L.P. CYLINDER
ISOTH. H.P. FACTOR PER 100 CU. FT. DELIVERED
ISOTHERMAL CURVE
INTAKE LINE
DIAGRAM LENGTH

FIG. 8. ELECTRICALLY DRIVEN COMPRESSOR

Gauge Pressure Pounds	Absolute Pressure Pounds	No. of Atmospheres	Correct Ratio of Cylinder Volumes	Intercooler Gauge Pressure	Isothermal Compression		Adiabatic Compression				Percentage of Saving over One-stage Comp.
					Mean Eff. Pressure	H. P.	Mean Eff. Pressure Theoretical	Mean Eff. Pressure plus 15% Friction	H. P. Theoretical	H. P. plus 15% Friction	
50	64.7	4.40	2.10	16.2	21.80	0.095	24.30	27.90	0.106	0.123	10.9
60	74.7	5.08	2.25	18.4	23.90	0.104	27.20	31.30	0.118	0.136	11.3
70	84.7	5.76	2.40	20.6	25.70	0.112	29.31	33.71	0.128	0.147	12.3
80	94.7	6.44	2.54	22.7	27.52	0.120	31.44	36.15	0.137	0.158	13.8
90	104.7	7.12	2.67	24.5	28.93	0.126	33.37	38.36	0.145	0.167	14.2
100	114.7	7.80	2.79	26.3	30.30	0.132	35.20	40.48	0.153	0.176	15.0
110	124.7	8.48	2.91	28.1	31.42	0.137	36.82	42.34	0.161	0.185	15.2
120	134.7	9.16	3.03	29.8	32.60	0.142	38.44	44.20	0.168	0.193	15.6
130	144.7	9.84	3.14	31.5	33.75	0.147	39.86	45.83	0.174	0.200	16.3
140	154.7	10.52	3.24	32.9	34.67	0.151	41.28	47.47	0.180	0.207	16.7
150	164.7	11.20	3.35	34.5	35.59	0.155	42.60	48.99	0.186	0.214	16.9
160	174.7	11.88	3.45	36.1	36.30	0.158	43.82	50.39	0.191	0.219	18.4
170	184.7	12.56	3.54	37.3	37.20	0.162	44.93	51.66	0.196	0.225	19.0
180	194.7	13.24	3.64	38.8	38.10	0.166	46.05	52.95	0.201	0.231	19.3
190	204.7	13.92	3.73	40.1	38.80	0.169	47.16	54.22	0.206	0.236	19.5
200	214.7	14.60	3.82	41.4	39.50	0.172	48.18	55.39	0.210	0.241	20.1
210	224.7	15.28	3.91	42.8	40.10	0.174	49.35	56.70	0.216	0.247	
220	234.7	15.96	3.99	44.0	40.70	0.177	50.30	57.70	0.220	0.252	
230	244.7	16.64	4.08	45.3	41.30	0.180	51.30	59.10	0.224	0.257	
240	254.7	17.32	4.17	46.6	41.90	0.183	52.25	60.10	0.228	0.262	
250	264.7	18.00	4.24	47.6	42.70	0.186	52.84	60.76	0.230	0.264	
260	274.7	18.68	4.32	48.8	43.00	0.188	53.85	62.05	0.235	0.270	
270	284.7	19.36	4.40	50.0	43.50	0.190	54.60	62.90	0.238	0.274	
280	294.7	20.04	4.48	51.1	44.00	0.192	55.50	63.85	0.242	0.278	
290	304.7	20.72	4.55	52.2	44.50	0.194	56.20	64.75	0.246	0.282	
300	314.7	21.40	4.63	53.4	45.30	0.197	56.70	65.20	0.247	0.283	
350	364.7	24.80	4.98	58.5	47.30	0.206	60.15	69.16	0.262	0.301	
400	414.7	28.20	5.31	63.3	49.20	0.214	63.19	72.65	0.276	0.317	
450	464.7	31.60	5.61	67.8	51.20	0.223	65.93	75.81	0.287	0.329	
500	514.7	35.01	5.91	72.1	52.70	0.229	68.46	78.72	0.298	0.342	

FIG. 7. TWO-STAGE COMPRESSION

The air indicator cards give an indicated horsepower of 83.6.

Therefore 83.6÷93=92 per cent. mechanical efficiency.

As stated above, loss in mechanical efficiency is determined by frictional resistance. This is a factor which can be largely controlled by the supervising engineer. In general it is desirable that attention be given to the lubrication system to insure that all rubbing parts are sufficiently lubricated at the following points: Bearings, crossheads, stuffing boxes and cylinders, as they constitute the chief sources of loss due to friction.

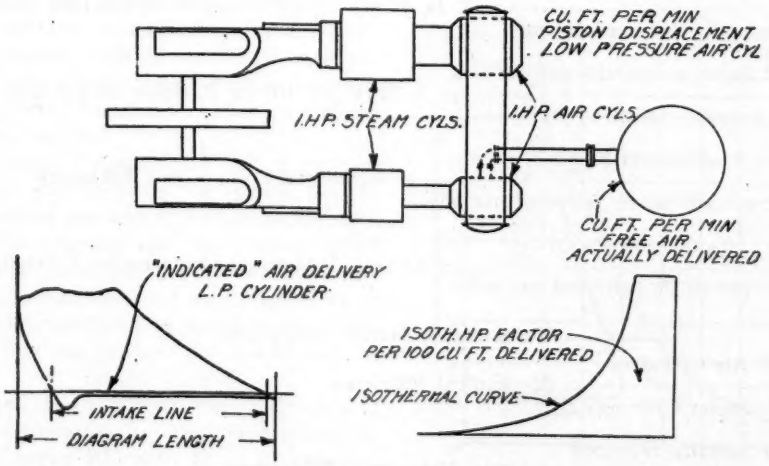

CU. FT. PER MIN PISTON DISPLACEMENT LOW PRESSURE AIR CYL
I.H.P. STEAM CYLS.
I.H.P. AIR CYLS.
CU. FT. PER MIN FREE AIR ACTUALLY DELIVERED
"INDICATED" AIR DELIVERY L.P. CYLINDER
ISOTH. H.P. FACTOR PER 100 CU. FT. DELIVERED
ISOTHERMAL CURVE
INTAKE LINE
DIAGRAM LENGTH

FIG. 9. STEAM DRIVEN COMPRESSOR

Bearings should be drawn up only enough to insure smooth operation, without undue pressure. Instructions covering the packing of stuffing boxes have already been given. Crosshead guides must be free enough to permit the crosshead to operate without undue pressure, and yet work without knocking.

AIR COMPRESSOR EFFICIENCIES

Different measurements necessary for calculation of efficiencies are given on the diagrams shown in Figs. 8 and 9.

Here following are stated the ratios of these measurements resulting in the respective efficiencies and performance measurements of an electrically driven and a steam driven compressor.

All compression efficiencies should be subject to correction to perfect intercooling if specified amount of water at specified temperature is not available.

COMPOUND VS. SIMPLE AIR COMPRESSORS

The theory of compound or stage compression is very readily understood. It is generally conceded that compound or stage compression should be employed, (a) with small capacity machines when pressures range over 125 lb., (b) with larger capacity machines when pressures range above 70 lb. The heat of compression increases with the pressure, therefore, the higher the pressure, the more difficult it is to reduce the temperature of the air to a point where efficient compression con-

FOR ELECTRICALLY DRIVEN COMPRESSOR

$$\frac{\text{B. H. P.}}{\text{E. H. P.}} = \text{Motor Efficiency.}$$

$$\frac{\text{I. H. P. Air Cylinder}}{\text{B. H. P. on Shaft.}} = \text{Mechanical Efficiency.}$$

$$\frac{\text{Free air actually delivered}}{\text{Piston Displacement}} = \text{Actual Volumetric Efficiency.}$$

$$\frac{\text{Length L. P. Intake Line}}{\text{Length Indicates Diagram}} = \text{Indicated Volumetric Efficiency.}$$

$$\frac{\text{Actual Volumetric Efficiency}}{\text{Indicated Volumetric Efficiency}} = \text{Slippage Efficiency.}$$

$$\frac{\text{I. H. P. Air Cylinder x 100}}{\text{Cu. ft. actually delivered per min.}} = \text{I. H. P. per 100 cu. ft. delivered per min.}$$

$$\frac{\text{E. H. P. Input at Switchboard x 100}}{\text{Cu. ft. actually delivered per min.}} = \text{E. H. P. per 100 cu. ft. delivered per min.}$$

$$\frac{\text{Isothermal Factor}}{\text{I. H. P. per 100 cu. ft. delivered per min.}} = \text{Isothermal Compression Efficiency.}$$

$$\frac{\text{Isothermal Factor}}{\text{E. H. P. per cu. ft. delivered per min.}} = \text{Overall Isothermal Compression Efficiency.}$$

FOR STEAM DRIVEN COMPRESSOR

$$\frac{\text{I. H. P. Air Cylinders}}{\text{I. H. P. Steam Cylinders}} = \text{Mechanical Efficiency.}$$

$$\frac{\text{Free air actually delivered}}{\text{Piston Displacement}} = \text{Actual Volumetric Efficiency.}$$

$$\frac{\text{Length L. P. Intake Line}}{\text{Length Indicates Diagram}} = \text{Indicated Volumetric Efficiency.}$$

$$\frac{\text{Actual Volumetric Efficiency}}{\text{Indicated Volumetric Efficiency}} = \text{Air I. H. P. per 100 cu. ft. delivered per min.}$$

$$\frac{\text{Isothermal Factor}}{\text{Air I. H. P. per 100 cu. ft. delivered per min.}} = \text{Isothermal Compression Efficiency.}$$

$$\frac{\text{Isothermal Factor}}{\text{I. H. P. Steam Cylinder per 100 cu. ft. per min.}} = \text{Overall Isothermal Compression Efficiency.}$$

$$\frac{\text{lbs. Steam per hour}}{\text{I. H. P. Steam Cylinder}} = \text{Steam Consumption per I. H. P. hour.}$$

$$\frac{\text{lbs. Steam per min. x 1000}}{\text{Cu. ft. free air delivered per min.}} = \text{lbs. Steam per 1000 cu. ft. air delivered.}$$

ditions and proper air cylinder lubrication obtain. For instance, in compressing air to 100 lb. terminal gage pressure in a single cylinder, the final temperature would be about 485 deg. F. Some of this heat would be absorbed by the cylinder walls and water jackets, but the final temperature would remain too high to insure efficient compression conditions and proper lubrication.

In Fig. 10 is shown a theoretical combined indicator diagram from a two-stage compressor. It is assumed that the compression follows the adiabatic curve in both cylinders, with perfect intercooling between.

In Fig. 10, AB = volume of low pressure cylinder; CD = volume of high pressure cylinder; both are drawn to the same scale. ACF = pressure to some designated scale; BEK (adiabatic curve) = relation between pressure and volume for any piston position, with no intercooling and no radiation through the cylinder walls.

In this curve the product $PV^{1.41}$ is constant (1.41 is the ratio between the specific heat of air at constant pressure and constant volume), where P = pressure and V= volume. BDH (isothermal curve) = relation between pressure and volume provided the temperature of the air under compression could be kept constant so that the product PV would also be constant.

Air taken into the low-pressure cylinder at zero gage pressure, is compressed along the adiabatic curve BE until at E it attains a pressure of 26.3 lb., equal to that of the intercooler, which allows the discharge valves to open and the air to pass into the cooler. In the intercooler, the volume of a definite weight of the air is reduced from CE to CD, so that the volume entering the high-pressure cylinder is less to the extent of DE, which is the same scale as CD and AB. This means that the given weight of air represented by the volume CE at a gage pressure of 26.3 lb., when cooled to the same temperature at which it was originally taken into the low-pressure air cylinder will be reduced in volume to CD provided the pressure of 26.3 lb. remains constant.

Air taken into the high-pressure air cylinder at 26.3 lb. is compressed along the adiabatic curve DG. At G the high-pressure discharge

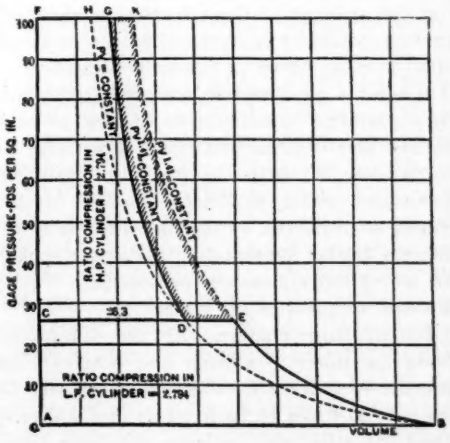


FIG. 10. COMBINED DIAGRAM

valves open and the air is discharged into the receiver at the desired gage pressure of 100 lb.

The shaded portion represents the power saving effected by the intercooler.

The saving due to the reduction in temperature between stages is not the only advantage of stage compression. The maximum temperature in each cylinder is reduced to a point where the heat can be more thoroughly drawn off by the water jackets surrounding the cylinder walls; also, the lower temperature in the cylinder is an insurance of good lubrication of piston, valves, etc.

As already indicated, the theoretical function of the intercooler in stage compression is to reduce the temperature of the air after it leaves the low-pressure cylinder to the same point at which it was first taken into that cylinder, before it enters the next stage cylinder.

Under practical working conditions, however, it will be found that the majority of coolers fail to accomplish this result and a reduction to within 5 to 10 deg. of the original temperature is considered a good accomplishment.

The intercooler consists of a shell containing a nest of tubes arranged in series or groups through which water flows successively, entering the bottom row and finding an outlet through the top row. Surrounding the water tubes is a series of baffle plates, which direct the flow of the air so as to split it up into thin films and insure intimate contact with the cold water tube surfaces. By reducing the spacing of these baffles as the high-pressure cylinder is approached the most efficient velocity of air in transit is attained.

When the air comes in contact with the cold tube surfaces, condensation of the moisture occurs, and it drips and flows down into the bottom of the shell. In order to drain this condensed water the intercooler is usually placed at an incline, so that the water will flow into the pocket surrounding the water separator where a drain cock is provided for the occasional removal of the water.

Temperature changes in the intercooler cause the tubes to expand and contract, and in order to provide for this it is customary for the best of tubes to be fixed at one end only, while the other end, including the water box, is left free to move with the tube plate.

AIR COMPRESSOR REGULATION

As for any other piece of machinery, the load factor of an air compressor is the average amount of work actually done, divided by the maximum capacity for work. The result represents the commercial efficiency of the machine, or in other words, the overall cost of production.

It is quite usual to install an air compressor to take care of the maximum demand and depend upon some automatic means of regulation or unloading to vary the output of the machine to fluctuating needs. This varies the horsepower input with the load and effects a saving in cost of operation.

It is further quite usual where the load will vary materially, especially in electrically-driven plants of large capacity, to install a number of small units and vary the number operating, keeping them at full load, to comply with changes of load, to assist in maintaining the highest overall economy. In such cases, regulation depends upon automatic starting and stopping.

The reduction in horsepower input with power-driven air compressors controlled by some form of partial unloading device is not in direct ratio to the reduction in output. For instance, in Fig. 11 is shown a series of cards taken from 28 by 17½ by 21-in. electrically-driven two-stage air compressor, operating at 185 r.p.m. and equipped with a four-step clearance regulator. It will be noted that at three-quarter load capacity, the horsepower input is 77.5 per cent; at half load, the horsepower input is 55 per cent; at quarter load, it is 30 per cent, and at no load 3.6 per cent. The difference is accounted for by the fact that the mechanical efficiency drops off rapidly with a decrease in load; for example, in this particular case at full load the efficiency is 94 per cent, three-quarter load 92 per cent, half load 87.5 per cent, and at quarter load 80 per cent.

Air compressor control devices are usually set by the manufacturer to meet the conditions imposed by the particular installation, and as the design of these devices varies with the different manufacturers, instructions of only a very general nature can be given here.

If the device fails to function properly, it is probably due to an obstruction in the way of dirt or other foreign substance, and not to a need for readjustment. It should be thorough-

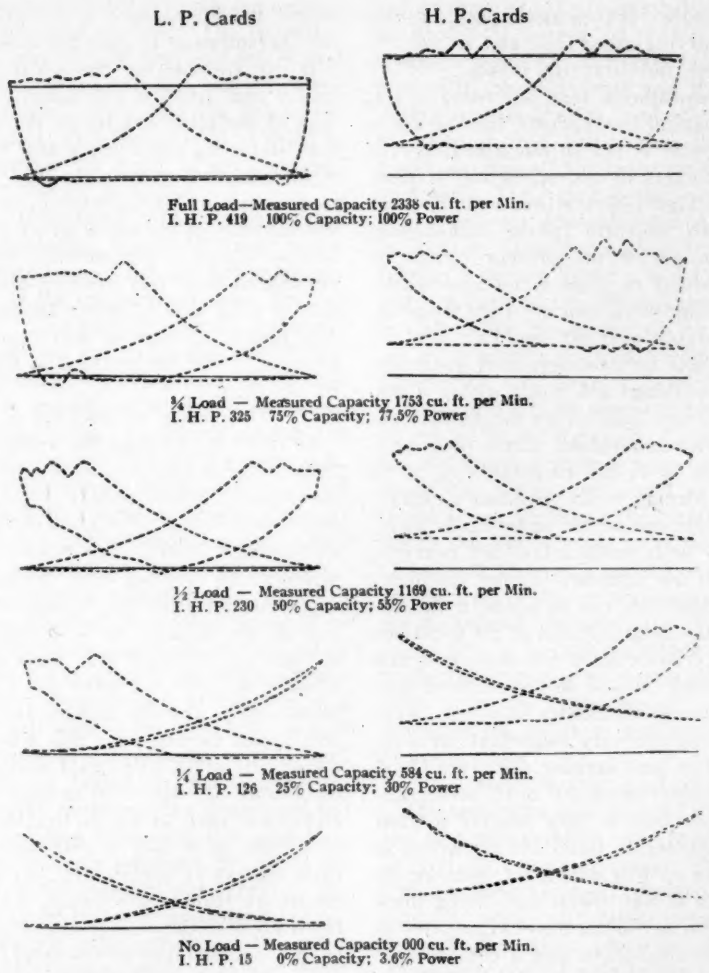

L. P. Cards
H. P. Cards
Full Load—Measured Capacity 2338 cu. ft. per Min.
I. H. P. 419 100% Capacity; 100% Power
¾ Load — Measured Capacity 1753 cu. ft. per Min.
I. H. P. 325 75% Capacity; 77.5% Power
½ Load — Measured Capacity 1169 cu. ft. per Min.
I. H. P. 230 50% Capacity; 55% Power
¼ Load — Measured Capacity 584 cu. ft. per Min.
I. H. P. 126 25% Capacity; 30% Power
No Load — Measured Capacity 000 cu. ft. per Min.
I. H. P. 15 0% Capacity; 3.6% Power

FIG. II

ly cleaned and care taken in reassembling to adhere to the adjustment existing prior to the cleaning.—*Power Plant Engineering.*

COOLING AND DRYING THE AIR IN DEEP MINES

By Sydney F. Walker

The difficulty which must be experienced in getting coal at depths of 5,000 to 6,000 feet will be principally due to the heat and humidity of the air. The present paper is intended to suggest that the difficulty may be overcome by treating each individual mine, each pair of shafts and the workings connecting them, in the same manner as modern cold stores are treated: cooling and drying the air entering the mine, and, if necessary, drying the air or portions of it in-bye. The great majority of modern cold stores are handled on the cold dry-air system. The air is exhausted from each cold chamber and passed through an apparatus that cools it and at the same time absorbs the moisture that the cooled air is no longer able to carry. The cold, dry air then returns to the cold chamber, where it receives a certain quantity of heat, and takes up any moisture that is given off by the produce held in the store, the higher temperature due to the heat taken from the store enabling it to ab-

sorb the moisture. It then again passes to the cooling and drying apparatus, and so on.

MOIST HOT AIR THE TERROR

It will be remembered that, according to Dr. Haldane's classical experiments, carried out a few years ago, it is not so much heat *per se* that affects workers in coal mines and in other places where high temperatures rule, as heat combined with moisture in the atmosphere. From figures before the present writer, it would appear that in some mines now working in the United Kingdom dry-bulb temperatures considerably over 80 deg. Fah. are reported, while wet-bulb temperatures in certain parts of the workings are found within a few degrees of the dry bulb. This means that the humidity of the atmosphere where these records are made is in the neighborhood of 80 per cent. According to Dr. Haldane's experiments, as the present writer understands them, comparatively high temperatures are bearable providing that the humidity is low; considerably over 80 deg. Fah. can be borne, if the humidity is in the neighborhood of 50 to 60 per cent. A little consideration will show that this is to be expected; it will be remembered that the perspiration which exudes from our sweat glands performs the very important office of cooling the body, and keeping down the blood pressure, this effect being due to its own evaporation. The action is very similar to that which is so common in India and elsewhere in the Tropics; of cooling wines, for instance, by wrapping them in wet towels and laying them in the sun. The wet in the towel evaporates in the heat of the sun's rays, and a considerable portion of the heat necessary to enable it to assume the vaporous condition is taken from the bottle and the contents. Similarly the heat necessary to enable the perspiration to evaporate is taken largely from our bodies; that is why we catch cold if we sit in a draft, or if our clothes get wet. In order that the perspiration may evaporate another condition is also necessary, viz., that the tension of the vapour already present in the air in the neighborhood is sufficiently low to allow of the forming of vapour from the perspiration. When the humidity of the air in which men are working is high, the vapour tension in the air is high and evaporation of the perspiration on their bodies is checked, and may be prevented entirely. The condition is very similar to that ruling in the Plains of India just before the rains; the atmosphere is so full of moisture that perspiration is almost impossible.

If the air entering the mines, therefore, is cooled and dried, it will behave in the workings of the mine exactly as the air does in a cold store; its temperature will be raised, and it will absorb any moisture that is present, up to the capacity of the temperature it reaches; the humidity of the air in which the men work will be lowered; perspiration will be carried on, with more or less freedom, and men will be able to work with a certain amount of comfort. The degree of comfort will depend upon the lowness of the temperature of the air, and of its humidity.

HOW TO ARRANGE IT

In order to arrange the matter on similar lines to those ruling in cold stores, it will be necessary to follow modern cold-storage methods, and to close over both pit tops; the air circulating continually round and round, through the cooling and drying apparatus, down the downcast pit, through the workings, and up the upcast. As with cold stores also, it could be arranged that fresh air should be allowed to enter the mine for a certain time occasionally, and the cooling and drying process again carried out; this will prevent the air getting stale, and could easily be done at week-ends. It would be necessary to provide airlocks at each pit top, so that the work could go on just as it does in cold stores, with very little ingress of outside air. By an airlock is meant, as readers are aware, a closed chamber leading to the outside air on one hand, and to the cold chamber on the other; in this case, the mine. An air-lock has two doors, which are only opened at intervals and one at a time. Mining men are familiar with airlocks; they have them in the connecting passages between the upcast and downcast pits. It would not matter whether the air was forced down the downcast pit or exhausted up the upcast pit; the cooling and drying apparatus would have to be in the neighborhood of the downcast pit, and all the air entering the pit would have to go through the drift or channel leading to the cooling and drying apparatus, and thence into the pit.

In those pits where a considerable amount of moisture comes away from the strata, cooling and drying, or drying apparatus alone, might be arranged for the air in that particular part of the mine, airlocks being provided

and the air being directed through the cooling and drying apparatus so fixed. The air entering the mine may be cooled to any extent that may be desired; it is merely a matter of the size of the cooling plant and the power required to work it; also the air may be dried to any extent within the limits of the temperature to which the air is cooled.

It will be remembered that the capacity of air for absorbing the vapour of water varies with the temperature of the air, and increases very rapidly as the temperature rises; thus, at 60 deg. Fah., saturated air contains about 6 grains of moisture per cubic foot, at 70 deg. Fah. it contains about 8½ grains, at 80 deg. Fah. about 11 grains, at 90 deg. Fah. about 14½ grains, and so on. As the air coming out of the mine passed over the cooling apparatus, its lowered temperature would deprive it of the ability to hold a certain weight of water, which would be deposited upon any convenient cold surface or absorbent that was present.

MOISTURE ABSORBENTS

In modern cold-storage work it is usual to provide an absorbent, a solution of chloride of calcium being the most common. This salt has a strong affinity for moisture; it is known as a deliquescent salt, and in the solid state it will attract moisture in air passing over it, and gradually become liquid. In the liquid state it easily absorbs moisture, the density of the salt in the solution becoming less and less. With calcium chloride solutions, the lower the temperature of the solution, the larger is the quantity of vapour that a given quantity of solution will absorb, other conditions being the same. In cold-storage work a rather dense solution of calcium chloride, which remains liquid at very low temperatures—very much lower than water—is cooled to a figure depending upon the temperature to which the air being dealt with is to be cooled. The cold brine is usually made to run over some metal surface, the air to be cooled being forced over the same surface, the cooling and drying being accomplished at the same time. One system that has met with great success comprises a number of corrugated galvanized iron plates suspended vertically, parallel with each other, with a small space between adjacent plates. There is a trough below the plates, and the cold brine is pumped from the trough to a perforated pipe above the plates, and is allowed to trickle down over the surface of the plates, and to drop into the trough below. The air to be cooled is forced by a fan through the spaces between the corrugated plates; its contact with the cold brine and the cold plates lowers its temperature, and at the same time the film of cold brine upon the corrugated plates absorbs all the moisture the air has to part with. The liquid in the trough below the plates becomes gradually weaker and weaker in calcium chloride, until when the density reaches a certain figure it is subjected to heat, and a portion of the liquid driven off by evaporation. The absorption of the vapour from the air gradually raises the temperature of the liquid brine, and lowers its capacity for absorbing moisture; it also lowers and lessens its ability to cool the air in contact. A complete apparatus, therefore, will be a refrigerating plant as described below, and some arrangement of liquid brine, wetting some metal surface over which the air is made to pass. The cooling and drying apparatus may be fixed in any convenient part of the connecting passage between the upcast and downcast pits. The only essential condition is that the whole of the air entering the downcast pit passes through it; it is safer to fix the apparatus near the top of the downcast pit, so as to guard against leakage of air.

REFRIGERATING ARRANGEMENT

The apparatus usually employed would consist of a refrigeration compressor, a condenser, and an expansion tank. The refrigerant, which may be ammonia, carbonic acid, or sulphurous acid, circulates round and round through the three parts of the apparatus. There is a coil of pipe in the condenser, into which the gas is pumped by the compressor at a certain pressure, depending upon the refrigerant and on the temperature of the water available for use in the condenser. The gas is condensed to the liquid form, very much in the same way as steam is condensed, and the condenser employed is a special form of surface condenser. There is another coil of pipe in the expansion tank, and the liquid refrigerant is allowed to flow into the coil, at a certain rate, depending upon the temperature required in the substance to be cooled. After the liquid has expanded to the gaseous state in the expansion coil, it is sucked into the compressor, compressed and forced into the condenser. In modern practice, a receiver for the liquid refrigerant is sometimes placed between the con-

denser and the expansion coils. It will be understood that the apparatus named, with the pipes connecting them together, form a closed circuit, in which the refrigerant is continually circulating as long as the apparatus is at work.

A second circuit is formed by the brine in the expansion tank; the cooling apparatus (which may consist of a grid of pipes through which the brine flows, or more usually, as explained above, some apparatus in which metal surfaces are wetted by the cold brine); and a pump, together with pipes connecting them. The brine is kept circulating through the expansion tank and through the cooling apparatus by means of the pump; it absorbs heat from the air in the air-cooling apparatus, which it delivers to the expansion coils as it flows through the expansion tank; the heat delivered to the expansion coils being transmitted via the compressor and the condenser to the cooling water of the condenser.

A third circuit is the air circuit, formed in this case by the two shafts, the workings, the connecting passage between the shafts, the cooling apparatus, and the fan; and the air is kept circulating round and round, continually taking up heat from the mine, and delivering it by way of the cooling apparatus, the compressor, and the condenser, to the cooling water of the condenser.

There is another apparatus that may be employed, with ammonia only as the refrigerant, in place of the compressor. It is called the absorption apparatus, and consists of two vessels partially filled with a solution of ammonia. One of these vessels is subject to heat, usually by the aid of steam pipes, and is constantly driving off the ammonia that has been held in solution, compression taking place in the gas space just as it does with steam in the steam space of a steam boiler. The compressed gas is delivered to the condenser, just as with the compressor; thence to the expansion coils, and thence to the other vessel, known as the absorber. In the absorber the solution of ammonia is maintained at a low temperature and a low density, and there is a constant exchange between the absorber and the generator, as the other vessel is called. There are accessories with this plant, arranged to clean and dry the gas before it passes to the condenser. The writer mentions this apparatus, as the exhaust steam from the winding and other engines might be used for the purpose.

The refrigerating apparatus employed must be large enough, not only to lower the temperature of the air circulating through the mine, but also to abstract the latent heat from the water vapour carried in suspension in the air, in order that the vapour may be enabled to condense, and be absorbed by the cold brine.

REFRIGERATION COMPUTATION

The principal unit employed in connection with refrigerating plant is the ton of refrigeration; it is the number of B.Th.U. that a ton of ice, supposed to be at freezing point, will absorb in passing to the liquid state in 24 hours. In the United Kingdom this means 318,080 B.Th.U. per 24 hours, or 221 per minute. This figure must not be confused with the number of B.Th.U. required to make a ton of ice. The latent heat of water that has to be extracted in order that it may be converted into ice at 32 deg. Fah. is 142 B.Th.U. per lb., and the above figure for the ton of refrigeration is obtained by multiplying 142 by 2,240. In America, where the net ton is only 2,000 lbs., the ton of refrigeration is 284,000 B.Th.U. per 24 hours. Stable ice is always at a very much lower temperature than 32 deg. Fah., so the above figure is only hypothetical; but machines are made to furnish so many tons of refrigeration, just as engines are built to furnish so many horse power.

The writer has made a rough estimate of the size of plant required to deal with 100,000. cub. ft. of air. In the first place, he has taken conditions that he believes actually exist in some mines in the United Kingdom at the present day—a dry-bulb temperature of 85 deg. Fah., and a wet-bulb temperature of 80 deg. Fah. This means a humidity of 80 per cent., at the above air temperature.

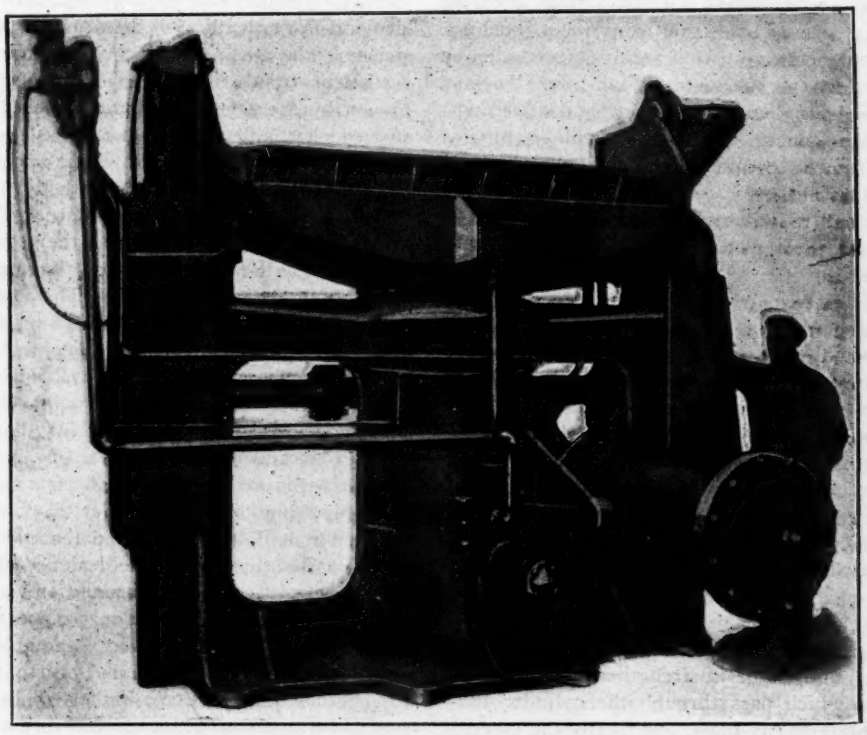
To cool the above quantity of air through 10 deg. Fah., and to absorb the latent heat of the vapour of water that would be deposited due to the cooling of the air, would require a refrigerating plant of rather over 1,000 tons; to cool it through 20 deg. Fah. and to absorb the latent heat of the additional moisture that would be condensed would require a plant of 2,100 tons; and to cool the air through 30 deg. Fah. and absorb the moisture would require a plant of 3,200 tons.

Air at 110 deg. Fah. and 70 per cent. humidity would probably not be so humid as in the case quoted above, due to its higher temperature; it would require refrigerating

plant of approximately 4,500 tons to cool it to 70 deg. Fah., and to absorb the latent heat of the vapour that would condense.

The power required to drive the refrigeration compressors might be taken for these large sizes at 1 h.p. per ton of refrigeration. Power would be required in addition for the brine pump and, of course, for the fan; also for pumping the cooling water for the condenser.

The writer is aware that the above figures are large, and that the apparatus would be costly, but if it enables us to get the coal at the lower depths, he makes out that the large cost would only be a small percentage of the value of the coal that its use would enable us to win.



A GIANT PNEUMATIC MOLDING MACHINE

The half-tone on this page gives us an idea of the appearance of the biggest pneumatic molding machine ever built. It weighs over 18 tons and is a very complete and up-to-date machine, built by the Cleveland Osborn Manufacturing Company, Cleveland, for the Bettendorff Company, Bettendorff, Iowa, for molding locomotive side frames. It is here shown on the erecting floor of the shop where it was built. When installed in the foundry for service it of course will not make such a show as it will be located in a pit and merely the table, roll-over device and track will be above the ground level.

The overall length of the roll-over table is 106 inches and the width of flask that may be accommodated, depending upon the depth, is from 48 to 60 inches. The pattern draw is 24 inches and the machine has a lifting capacity of 8500 pounds at 80 pounds air pressure. Two of these machines have been built for the Bettendorf Co. for use in its steel foundry. It will be noted that the entire frame is a single casting and it is practically a two-piece machine. The load is handled on approximately balanced centers. The machine is equipped with a forced feed oiling system and adjustable air-balanced piston valves. The castings are of steel and semi-steel construction.

The amount of time and labor saved by this machine is tremendous. It not only jar-rams the mold, but rolls it over, draws the pattern and deposits the mold on a run-out rack from

which it is lifted to the floor by a crane for core setting, closing and pouring. This machine is indicative of the tendency in molding machine manufacture toward the installation of larger units and the economies that may be effected on large molds are much greater proportionately than on small work.

COMPRESSED GAS FOR MOTOR VEHICLES IN ENGLAND

The only instance in which compressed gas has been regularly used for some years is that of the Neath Corporation tramways, where the receivers are charged up to a pressure of 200 lb. per sq. in., the cost of compression working out to less than 5 per cent. of the total cost of the gas. At Neath, however, there are facilities for obtaining a fresh charge at reasonable and convenient intervals, so that conditions are scarcely to be compared with those in the metropolitan area. In fact, the London General Company find that conditions in general call for the employment of a very much greater degress of compression than has hitherto been found practicable, with the result that their new containers are to be charged to a maximum pressure of 1,000 lb. per sq. in.

The extremely high pressure involved has required the employment of storage cylinders of special construction. Two of these cylinders are used on each omnibus, being placed one on either side beneath the interior seats. The cylinders have each a compressed gas capacity of rather more than 600 cu. ft., so that a run of 20 miles may be made before recharging becomes necessary. The main body of the cylinders, composed of copper, is 10 in. in internal diameter and 9 ft. in length, while the two ends are formed of circular steel plates so fitted as to make a perfectly gas-tight joint on a radius formed on the ends of the copper tube. The whole is strengthened by six steel stays, which pass through the cylinder from end-plate to end-plate, and finally the exterior periphery of the cylinder is wound with three layers of steel tape 1-16 in. thickness. It is pointed out that this principle of construction will avoid bulging or sectional fracture, while any tendency towards distortion will be in the form of elongation, which is provided against by the longitudinal stays.

The two cylinders are connected in parallel, by a ⅜ in. pipe, to a main reducing valve which is a combination of a cut-out and diaphragm arrangement, and by means of this valve the gas pressure is reduced to some 2 lb. per sq. in. The gas then passes through a secondary valve into a flexible fabric container which operates as an expansion chamber, and practically as a governor. For instance, when the fabric chamber is fully extended it actuates a valve spindle which cuts off the supply, the surplus gas passing by way of a by-pass into the chamber of the reducing valve, which again cuts off the high pressure supply. Conversely, once the gas is emitted from the engine control valve the fabric chamber contracts and the series of operations is reversed so that a further supply is received from the containers. The system is particularly commendable in that it is entirely self-acting and demands practically no attention from the driver. The advances which have been made in the construction of valves for the purpose is shown by the fact that stuffing-boxes having proved unreliable have been replaced by seals formed by a combination of grease and rubber rings inserted beneath the valve body.

For recharging the London General Company will have in operation at their Cricklewood depot a Reavell compressor having a capacity of 15,000 cu. ft. an hour. This compressor will be coupled to a series of storage cylinders of 30,000 cu. ft. capacity, controlled by a hydraulic accumulator, which is introduced for the purpose of ensuring the maintenance of a constant pressure. The whole installation is to be so arranged that a number of omnibuses may be recharged simultaneously from a common pipe line. In the earlier days of gas traction it will be remembered that the opinion prevailed that the engine designed primarily for petrol (gasoline) consumption was capable of yielding with gas only some 85 per cent. of the maximum power obtainable with petrol; but it was then pointed out that were the engines designed for a higher compression the power ratio would compare very closely with that given for petrol. This appears to have been corroborated by experiments, for in a series of trials with the new arrangement it has been shown that the power obtained from the engine is equivalent to that obtained with petrol. The running figures which have been obtained are decidedly instructive in that they bear out previous estimates as regards the gas equivalent of petrol

(in this instance the average relations being 280 cu. ft. of gas per gallon of spirit), while the average saving in cost, which is very considerable at low speeds, amounts to rather more than 50 per cent. as compared with petrol. The normal consumption of gas has been shown to be 35 cu. ft. per mile on a straight 10-mile journey.

As in the case of most gas vehicles the London General omnibuses are fitted with petrol supply arrangements for use in case of emergency. For this reason the ordinary petrol carburettor is retained. The change from one fuel to another is easily effected by engaging whichever throttle lever it is required to operate. A particularly novel feature of the new omnibuses is the use of gas instead of electricity for lighting. For this purpose a special reducing valve and governor are carried, the lighting supply being distributed at a pressure of 10 lb. per sq. in. Incandescent mantles are employed, and each is enclosed in a small fused silica protector. The merit of the system, however, lies in the fact that, whereas the usual electric generator installation weighs something approaching 3 cwt., the necessary apparatus for gas lighting runs to little more than 22 lb.—*London Times Engineering Supplement.*

THE SALVAGE OF THE ONWARD

Many interesting tales could be told of how the Admiralty Salvage Department have saved ships during the war. Some are romantic; others thrilling. But novelty, combined with mystery, attaches to the salving of the cross-Channel steamer Onward, which plied between a French port and a Southern port on the English coast. The boat was moored at the English port, and at about 11 o'clock at night, for no reason that could then be discovered, the fore part of the ship burst into fierce flames. In order to prevent the fire spreading to the quay the Onward was towed a little distance away and scuttled. She listed and rolled on to her side in comparatively shallow water. Then the salvage men got to work. Alongside the quay is a railway track, and the idea struck them of using locomotives to raise the sunken steamer. Strong wire ropes were fastened round the direlict bulk and worked through tripods fixed on the quay. These ropes were attached to the locomotives, which commenced the herculean task of literally dragging the big ship into an upright position. The five railway engines put on full steam and commenced to tug with all their strength. It was a tremendous struggle. The locomotives panted and strained, but for a time were unable to move. Eventually their combined efforts began to tell. The vessel was slowly heaved from her resting place, and with the aid of tugs kept clear of the quay and dragged into an upright position. She was patched up temporarily and towed to the Thames for repairs.

GRAIN DUST EXPLOSIONS AND FIRES*

Between March, 1916, and October, 1917, dust explosions caused the destruction of four of the largest grain and cereal plants in the United States and Canada. In these disasters 24 people were killed, 38 were injured and property to the value of $6,000,000 was damaged. One of these was an explosion and a consequent elevator fire in which was destroyed grain enough to supply bread rations for 200,000 soldiers for a year. During the same period of time a dust explosion occurred in a sugar factory, killing 12 persons, injuring 24 more and destroying almost $1,000,000 worth of foodstuffs and property. And such disasters are occurring continually. During the month of April, 1918, a carelessly dropped cigarette stub resulted in an explosion and the consequent destruction of a warehouse with its surrounding property, a total loss of $2,000,000. A few days later a flour mill, containing a great store of wheat, oats and barley, was destroyed by a dust explosion, which at the time was ascribed to the use of a blow-torch for babbitting a bearing.

HOW IT WORKS

If you want to start a fire in a stove, you do not try to set fire to a large stick of wood with a match. Nor do you stop at splitting this stick into smaller pieces. To get a good crackling fire immediately, you reduce one of your big sticks to shavings, touch a match to the bunch and off it goes.

Now, suppose these shavings were ground to a coarse powder, spread out in a thin layer, and ignited. You would find that your powder would burn very rapidly. If this powder were ground quite fine, and scattered about so that it became mixed with the air of the room, you could ignite it with a flame not even as large as that of a match. A very

*U. S. Department of Agriculture.

small electric spark, or a spark made by striking a piece of steel on a stone might cause this dust-laden air to take fire and burn so rapidly that it would produce an explosion. And wood dust is not the only dust of which this is true. Almost any kind of dust containing carbon explodes under favorable conditions. Among such dusts are grain dusts, flour dusts, sugar dusts, rice dusts, feed dusts, paper dusts, cotton dusts, leather dusts, wood dusts, cork dusts, and fertilizer dusts.

NATURAL GAS STORAGE*

By L. S. Panyity

The question of natural gas supply is receiving careful consideration in many parts of the country, as in the winter months it is quite a problem to have on hand sufficient gas to satisfy the demand. Increasing the output of wells by the application of vacuum has been tried with various results and large companies have attempted to keep up the supply with gas compressors. The possibility of storing natural gas in the sands of exhausted gas pools has been tried in a few instances with satisfactory results. This method may prove of practical value in solving the problem, especially in the case of towns that formerly obtained gas from their immediate vicinity, but now must search for new pools.

In all cases, only part of the available supply is utilized during the warm weather, so that many wells are shut in, yet during the winter months the supply is not sufficient even with all the wells on the line. In such cases it would be of great value if a large volume of stored gas were on hand, obtained through wells that would have been standing idle during the summer.

Idle producing wells having considerable "rock pressure" will force gas into the exhausted, or storage wells, and this gas will be used only when the regular supply falls short, Fig. 1. If two gas wells of different pressures are connected, the one having the greater pressure will feed the other, until the pressures are at an equilibrium. The same results will be obtained if an exhausted gas well is connected to a high-pressure gas line. High-pressure lines equipped with regulators near the town plant have considerable pressure, so that storage wells connected to such a line will receive gas from the line as long as the line pressure is greater than the well pressure. During a period of heavy consumption of gas, the pressure on the main line is greatly reduced, so that gas from the storage wells will flow into the lines. An arrangement of this kind will work automatically, the flow of gas into or from the storage wells depending on the pressure carried in the line.

It is advisable in most instances that the flow into and from the storage wells be regulated by means of gates, instead of automatically. In addition, the volume of gas should be metered as it is forced into or passes from the wells; the pressure also should be noted. By properly charting the meter and pressure records, the characteristics of the individual wells may be determined.

The geological conditions existing in the storage field, as well as in the producing field, must be taken into consideration. Best results are obtained where the storage reservoir is in

*Trans. Am. Inst. Mining Engineers.

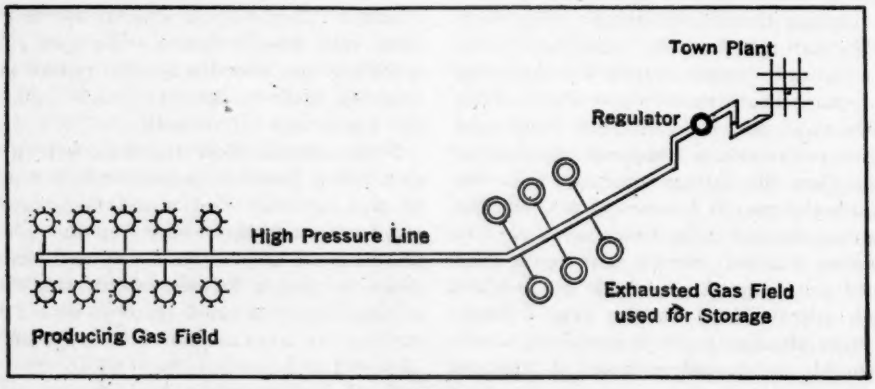


FIG. 1

a shallow sand and the producing horizon is deeper, so that the producing sand will have a higher pressure. This will have a tendency to reestablish the original rock pressure in the artificial reservoir. It is unlikely that a rock pressure greater than that which existed originally can be obtained. A lenticular-shaped sand body is preferable, as good control over the entire reservoir is necessary. The location of all wells that have been drilled must be known and put in such a condition that they may be used; if this is not possible the wells must be properly plugged.

In some instances the sand used for storage may make large quantities of water; a difficulty that may be overcome by pumping. Best results are obtained by drilling a pocket below the sand in which the water may accumulate and from which it may be pumped through the working barrel, in the same way as it is customary to pump oil; the storage and recovery of the gas being through the casing-head, Fig. 2.

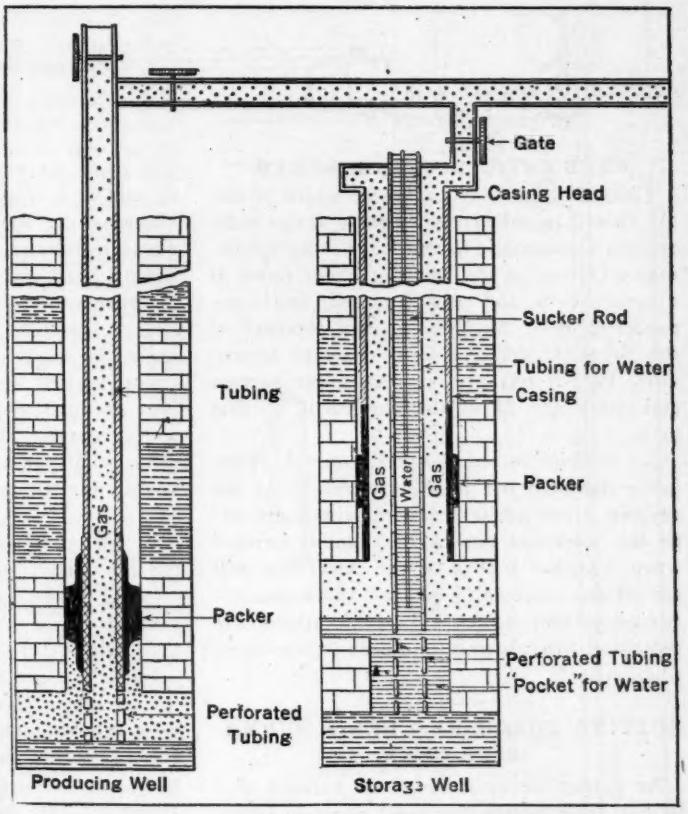


FIG. 2

This storage method may be used to advantage in many towns; for instance, Tiffin, Ohio, formerly the center of a large gas-producing area, but now dependent on outside sources, which in times of great demand are not sufficient for the needs of the town. It may be possible to find nearby an exhausted gas pool in such condition that this method may be tried. The system allows considerable latitude and may be installed to suit the requirements of the particular case.

An Emergency Placing of Pumping Equipment, aggregating a total capacity of 20,000,000 gal., was completed in 24 hr. at the Old Dominion mine, in Arizona, according to its report for 1917, with the exception that the transfer of a cable from one shaft to another was not finished.

HOW WETTING COAL IMPROVES COMBUSTION

Another characteristic of Iowa coal which is common to many low-grade fuels, is that wetting the fuel improves the combustion appreciably. It is not to be understood that the addition of water helps combustion from a chemical standpoint, but it certainly does from a physical standpoint. The water should be added at least two hours before firing so as to be absorbed thoroughly by the fuel. The physical action is three-fold: First, the sifting of coal through the grate is diminished; second, the fuel bed is made more compact; third, the steam generated by the moisture in the coal cracks open the pieces of coal, presenting new clean surfaces for quick combustion. These advantages more than offset the detrimental effect of excess moisture, which of course must be evaporated and superheated up to the temperature of the gases escaping from the boiler.—*T. A. Marsh in Power.*

PNEUMATIC RIVET BREAKER

The cut above shows a device which probably should be called a pneumatic sledge rather than a pneumatic hammer. It is for knocking or cutting off the heads of boiler rivets at a single blow and was designed, and since patented, by A. M. Roberts, tool foreman of the Bessemer & Lake Erie shops at Greenville, Pa. It has proven a complete success and there are 23 in the car yards at that point.

No description seems to be required. When being operated the lever is normally in the reverse stroke position and remains there until the workman pushes the handle forward when it strikes a blow on the chisel that will cut off any rivet up to an inch and a quarter. A rivet catcher, not here shown, is attached to the chisel for catching the heads of the rivets when cut off.

CUTTING TORCH RESCUES A SUBMARINE CREW

An extraordinary story of the salvage of a British submarine which went down in Gaenloch lock near the Clyde was recently cabled by the Associated Press. The submarine had seventy-three persons on board, including naval contractors and men from the yard where she had been built. The order was given to submerge and she was just beneath the surface when water began to pour into her aft and she descended stern down to a depth of fifteen fathoms. An inspection showed that the ventilating shaft had been left open and thirty-one persons in the rear of the vessel were immediately drowned. The forepart was shut off and the forty-two persons there were saved.

A few hours passed before divers were sent down on what they thought a forlorn hope so far as bringing any one up alive was concerned. Reaching the bottom, they discovered that the stern of the vessel was imbedded in many feet of mud. Knocking at the hull, they were amazed to hear a responsive tapping.

High-pressure bottles were brought into use and Captain Goodhart undertook, with their aid, to be projected through the conning tower and shot into the water with the hope of reaching the surface and giving information regarding those below. He was shot forward, but his head struck a beam and he was killed. Another officer volunteered and was fortunate to reach the surface and give information about the condition of the others below. Rescuers inserted through a water flap a flexible hose through which air, food and chocolates were passed. The entombed men asked, by means of Morse signaling, for playing cards "to beguile the tedium of waiting," as one of them said.

Strong wires were put around the vessel and the air bottles were utilized to blow out the oil fuel stowed forward, which enabled the vessel to drive upward until her bow was well above the water in a vertical position.

Immediately a big hole was cut in her with oxy-acetylene torches and the forty-two men were brought out and conveyed to an infirmary. They had been below twenty-four hours when Captain Goodhart made his attempt, and altogether the party was down fifty-seven hours before being saved.

To Captain Goodhart has been awarded posthumously the Victoria Cross.—*New York Times.*

UTILIZATION OF AIR POCKETS

By C. Erb Wuench

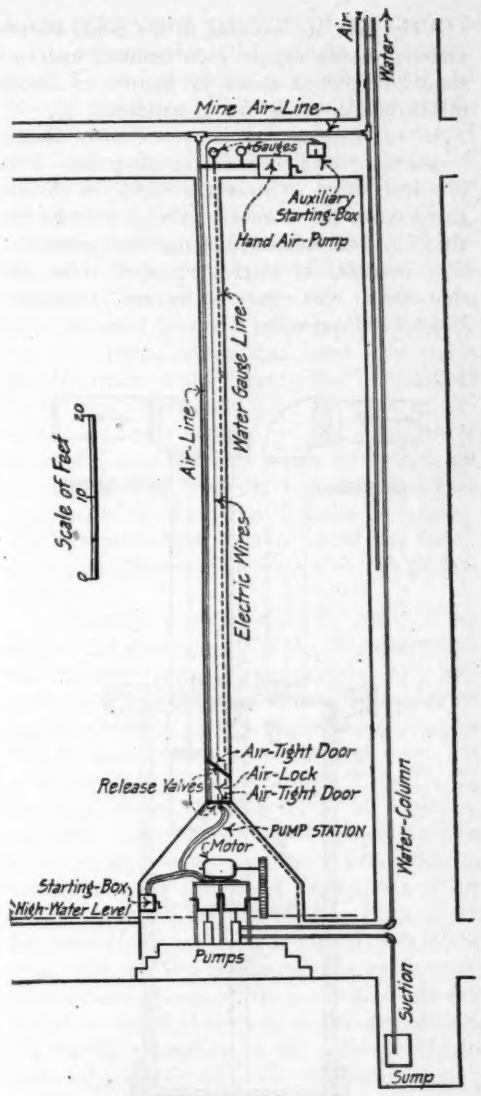
During the unwatering operations at the Yak mine, in the Leadville district, it was noticed that in the backs of several old stopes air-pockets had been formed. Even though the water had risen considerably above the highest points in these stopes, the small cavities in the back were entirely unwetted. Such air-pockets have saved the lives of miners. This suggested to me the possibility of designing underground pumping-stations utilizing the principle of the hydraulic "diving-bell."

In the history of a great many mines that have been drowned it is on record that if only an hour or two more time could have been

had in which to make the necessary repairs thousands of dollars of expense in unwatering might have been saved. In the Yak mine, owing to a sudden inflow of acid water that corroded the pumps of an intermediate pumping-station and caused an excessive flow to be handled by the pumps at the bottom, the motors burnt out. The sudden flow of acid water was due to the Moyer mine, an adjoining property, having been abandoned. There being no underground connection at depth the water, which was formerly handled by the Moyer pumps, backed up through the old stopes and took into solution the sulphates of iron and zinc formed by the exposure of sulphides to oxidation for a number of years, and then the waters charged with these sulphates found their way into the Yak mine and corroded the intermediate pumps.

By referring to the accompanying sketch, the general design of this style of pumping-station can be readily comprehended. The station is cut out so that the area at the back will be contracted as shown in the sketch. A raise will be driven from the back of the station to the level above. Through this raise an air-line and a water-gauge line and the wires to the auxiliary starting-box will pass. There will also be a ladder-way. At the bottom of this raise there will be two air-tight doors forming an air-lock. When everything is running smoothly, these doors will be open and the heated air, which is usually present in the back of a pump-station owing to the heat from the motors, will pass up the raise and fresh air come in at the bottom. This will have the minor advantage of having the electric motors working in a cooler atmosphere. In case anything happens to the motors or pumps, the lower air-tight door is closed, and as the water rises in the mine sufficient air will be admitted through the air-tight door to balance the water-pressure due to the rising water. The air may either be obtained from the mine air-line, or, if this is out of order also, the small amount of air necessary can be forced down through a hand air-pump as shown. Two gauges are provided: one, a water-gauge to measure the hydrostatic pressure of the water in the mine, and the other, to measure the pressure of the air that is forced into the pump-station to balance this hydrostatic pressure.

At the bottom of this raise is an air-lock.

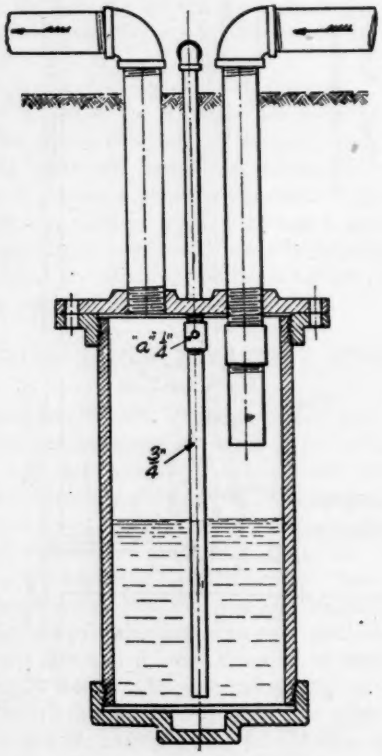


PUMPS LOCATED IN AIR POCKET

Men can go down the raise to the top of the pump-station, close the upper air-tight door, and by releasing the valve in the lower air-tight door they can gradually become accustomed to the pressure; then they open the lower air-tight door and pass into the station to make the necessary repairs. It can be seen that the men can work for a considerable time before the pressure will become too great for their lungs. The raise can be made large enough so that the various parts of machinery can be hoisted in and out of the pump-station.

When men are working in the pump-station under pressure, caustic soda (sodium hydrate) should be placed about the station to absorb the carbon di-oxide that is exhaled.

An auxiliary starter is shown in the sketch on the same level as the hand air-pump. This is merely used to start the motor to obviate going down the manway, passing through the air-lock, and thence entering the pump-station, in order to start the motors when the shut-down was due to power trouble.—*Mining and Scientific Press.*



DRAINING AIR PIPING FOR PNEUMATIC TOOLS

It will be remembered that in our December issue there appeared an article with the above title and the cut here reproduced will be recognized as having appeared in illustration of that article. It must be noted, however, that an important addition has been made in the cut as here shown. The change is very slight, consisting merely in the showing of a ¼ in. equalizing hole drilled in the side of the small air pipe near the top of the receiver. This is very necessary for the successful operation of the device. The article was from a Standard Practice Bulletin of the Emergency Fleet Corporation and the change is made upon information since received.

DUST ABATEMENT IN MINES*

By W. O. Borcherdt

Dust in mine air is dangerous and objectionable more or less in proportion to its silica content; and the well known diseases phthisis and silicasis commonly result from the continued inhalation of dust high in silica. It is not generally recognized that all dust is injurious, and that it should be the business of mine operators to suppress dust of any character, and to employ the same perseverance and intelligence which are, or should be, applied to the more obvious dangers due to faulty sanitation or unsafe practices. It is sometimes assumed that because high silica dusts are the most injurious, other dusts, unless present in quantities offensive to the senses, may be ignored. Figures have been advanced showing that the incidence of tuberculosis among coal miners is no greater than among surface workers in the same locality, and it has even been stated that the inhalation of local dust is supposed to confer a partial immunity to tuberculosis.

Those who are operating mines in which the rock dust is not siliceous, or in which it is siliceous to only a slight degree, have, of course, a less serious problem to face than those whose work is carried on in the highly siliceous rocks; but the dust problem exists none the less, and it behooves operators to recognize and solve it promptly and voluntarily, in order to make unnecessary eventual interference and regulation by the state.

NATURE AND EXTENT OF THE DUST EVIL

So far as I am aware, there has not been in this country any legislation directed at the dust evil which is as drastic as that of South Africa; but that conditions have existed, in certain parts at least, which paralleled those in the African gold mines is shown by the admirable work in the Joplin district.

(Continued on page 9051)

*From a paper before the Seventh Annual Congress of the National Safety Council.

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CONTENTS

Compressing Air Efficiently..... 9027
Cooling and Drying Air in Deep Mines.. 9037
Giant Pneumatic Molding Machine..... 9041
Compressed Gas in England..... 9042
Salvage of the Onward..... 9043
Grain Dust Explosions and Fires..... 9043
Natural Gas Storage..... 9044
Wetting Coal Improves Combustion.... 9045
Pneumatic Rivet Breaker..... 9046
Cutting Torch Rescues Submarine Crew 9046
Utilization of Air Pockets..... 9046
Draining Air Piping..... 9048
Dust Abatement in Mines..... 9048
Rossiter Worthington Raymond..... 9049
A Great Pneumatic Engineer..... 9050
Miners' Safety and Health Almanac.... 9051
Burning Pulverized Coal..... 9054
Notes 9056
Patents 9058

ROSSITER WORTHINGTON RAYMOND

The following heart-full tribute to the memory of Dr. Raymond by the editor of *Mining and Scientific Press,* which we reprint entire from the issue of Jan. 11, will be read with high appreciation by all who know him, and it should commend itself equally to these who had not that high privilege.

On the last day of 1918 there died, at Brooklyn, New York, the most notable figure in the history of mining in America. Others may have directed bigger mining and metallurgical operations, others may have achieved a greater share of the success that is measured by money, others may have invented or designed a larger number of the methods or processes used in the winning of metals, but no man exerted so great an influence for so long a period of time as Rossiter Worthington Raymond—"the Doctor," as he was familiarly and affectionately known to the profession.

In the adult portion of his 78 years of life he saw the development of the American mining industry from a mere beginning to a majestic maturity; and in that development he played a notable part by the help and stimulus that he gave to two generations of men. He was the comrade of Clarence King, J. D. Whitney, James D. Hague, S. F. Emmons, and that earlier generation of scientific men to whom we owe the application of geology to mining and the systematic exploration of the continental area that was thrown open to the prospector as soon as the railroad joined the East with the West. He was the guide, philosopher and friend of the generation that followed, of many of the young men now directing the big enterprises of this country. He influenced the men that now influence others.

When he was born, in 1840, the mining industry of the United States had made a feeble start; when he went to Freiberg in 1860 there was no mining school in this country; when he served in the Union army the discoveries of gold in California and of silver in Nevada had laid the foundation for the mineral development of the West; and when he was Commissioner of Mining Statistics, from 1868 to 1876, he gave a lead to the application of science to the art of mining in America. Long the dean of the mining profession, he has been its spokesman from a time as early as most of us can remember. In him a profession usually

inarticulate found an eloquent exponent; through him the public learned to appreciate the breadth of culture that is required by an accomplished engineer.

From his father, the editor of the New York "Times," he inherited his ability as a writer and an expositor, an ability that he developed to an effectiveness unmatched in our profession, not only as a public speaker, but in the more systematic duties of lecturer on economic geology and of editor of two mining journals, notably the "Engineering and Mining Journal," on which he collaborated for many years with Richard P. Rothwell. His abilities, however, were put to their maximum usefulness when he became Secretary to the American Institute of Mining Engineers in 1884. As editor, as organizer, as permanent executive, he managed the affairs of the Institute until his retirement in 1910, and so successfully that it became a national institution of the first rank.

He brought his vivid personality so actively into play, he marked the Institute so strongly with his own identity, that for 25 years it might with truth and credit have been known as the Raymond Institute. This condition had the defect of its qualities and eventually called forth the need for reorganization, to which he objected so strenuously that the last decade of his life was clouded by a controversy in the course of which he became estranged from several of his best friends. But that disagreement is now placed in its true perspective and is remembered only as the manifestation of an exuberant egoism not uncommon in great men. He was a great man, an inspiring figure of a man.

We like to think of him at the meetings of the Institute; how he would rise and look about him, then speak clearly, incisively, and humorously, making the rest of us seem a blundering lot of incompetents. He was the mainspring of those meetings; he saved the dullest from being a failure; he was ready for any exigency. This is not the occasion for touching upon the many other facts of his character: his legal career, for he was admitted to the bar; his church work, for he was superintendent of the Sunday-school, teacher of a bible-class, and preacher at Plymouth Church; of his skill in many ways, from playing chess to writing stories—he was amazingly versatile; these aspects of his many-sided personality demand more considered treatment than is permissible here. He had the gift of leadership, winning the devotion of old and young, of men and women alike; he was kind to those in distress and generous to those needing help, whether mentally or financially; he was religious in a glad and unaffected way; he was a maker of fun and of happy hours; he was an inspiring companion and a beloved comrade. For ourselves we tender to his memory the homage of a fellow journalist, the respect of a fellow engineer, and the affectionate remembrance of a friend.

A GREAT PNEUMATIC ENGINEER

Walter V. Turner, manager of engineering for the Westinghouse Air-Brake Co., died January 9. Mr. Turner was one of the foremost pneumatic engineers in the world, and had over four hundred inventions, covered by United States patents, in use on most railways of the world and in many large industrial plants. One invention alone: viz., the "K" triple valve, is valued at $28,000,000. In 1906 when the New York subway was taxed beyond its capacity and the formulation of some plan of relief became inevitable, it was finally decided to "speed up" the car motors. When Mr. Turner was consulted upon the subject he made the startling statement that relief could be obtained without any change other than installing his newly devised brake, which could produce a quicker and shorter stop than any brake heretofore employed. The new brake was tried and as a result the subway is operating with a triple capacity and is still satisfactorily providing for the traffic congested city of New York. The control valve adopted by the New York Central R. R. in 1909 and the universal valve, the first successful electro-pneumatic brake ever devised, by the Pennsylvania Railroad in 1913 are inventions of equal importance. Mr. Turner was an American citizen, but he was born in Epping Forest, Essex county, England. He came to the United States in 1888; became secretary and manager of Lake Ranch Cattle Co., Raton, N. M., in 1893; was engaged by the Atchison Topeka & Santa Fe Ry. in 1897, where he developed his first patent; and entered the services of the Westinghouse Air Brake Co. in

1903. He received the following appointments with the latter company: Mechanical engineer, 1907; chief engineer, 1910; assistant manager 1915, and manager of engineering, 1916.

MINERS' SAFETY AND HEALTH ALMANAC

The U. S. Bureau of Mines has published a useful almanac with the above title. It is a pamphlet of 48 pages, with one page for each month and safety hints or historical data for each day, sun's rising and setting, moon's phases, etc. In addition to this there is given a great variety of matter relating to health and safety, correct and comfortable living and other matters, making the book likely to be frequently referred to.

(Continued from page 9048)

Respirators do not, in general, present any hope of a solution, because they are objectionable to the miners, are partly effective only when properly cared for, hamper respiration, and will, therefore, be worn by only exceptional men or under conditions where unusually strict discipline can be maintained. To make such a provision effective it would be necessary for nearly all underground men to wear them. Moreover, ordinary respirators do not remove from the air dust particles less than five microns in diameter, and much of the dust which has been shown to be harmful is less than three microns in diameter.

WATER SPRAYS

Water sprays directed into the dust as delivered from the drill hole, and dust collecting bags intended to catch the dust and prevent its distribution through the mine atmosphere, have been constructed in many forms. It is my conclusion that none of these methods is effective on a practical scale. Elsewhere the opinion has been expresssd that the best hope for a practical solution of the problem lay in the use of drills employing hollow steel through which water is injected into the hole. This would appear to be the ideal method, because, as frequently pointed out, this type of drill not only allays dust, but gives a higher drilling speed. In some mines the conditions resulting from the operation of such drills have been entirely satisfactory, from both a hygienic and a mining point of view. In others, however, especially in those in which conditions demand overhand stoping and a large amount of raising in dry ground, the water feed drills have not been a success, partly because of mechanical imperfections, and largely owing to the attitude of the miners, who generally insist that they would rather breathe dust than get wet.

As the general features of this problem and the most practical methods for its solution have been covered in other papers and in the official reports of the South African and Australian Dust Commissions, it occurred to me that the best hope of contributing something of real value lay in the direction of determining the actual practical operating results with the various types of water feed drills in different mines under diverse conditions. For the purpose of securing this information I sent a questionnaire to 47 representative mines in the United States and Canada, to which 26 have made reply.

The data thus received have been tabulated and a summary of the table shows 11 instances of the use of respirators, only five of which were considered successful; four cases refer to raising, and one case refers to overhand stoping.

One operator suggests that improvements in respirators could be made by following the design of military gas masks; and, although it seems probable that a respirator could be developed along these lines which would be highly effective in stopping dust of even a few microns in diameter, the difficulty of getting men to use such respirators would be greater than is the case with the existing types, which, though less effective, are also lighter and not so objectionable.

A man cannot chew or smoke while wearing a respirator; and I think no one familiar with actual problems of protecting men from themselves and others will fail to agree with the statement that even men of more than average intelligence will not voluntarily and constantly use safety guards or precautions if these interfere with their comfort, convenience and fixed habits. This is unfortunate, but it is a fact, nevertheless. In practice it is not sufficient to point out the existence of a danger and the means by which it may be guarded against, but the men must be continuously and intensively educated in order to secure their co-operation in self-protection; and no amount of education will insure the adoption of a safety device which results in

discomfort or inconvenience to the wearer. A sidelight on this problem is obtainable from the sand-blast art, where, originally, various types of masks and respirators were used, but in which present practice provides that the operator work on the outside of the chamber in which the sand blast is being used.

CONSTRUCTION OF RESPIRATORS

I have experimented in the construction of respirators containing a filtering element or cartridge which would be inexpensive, readily inserted and removed, and would have a filtering surface of such dimensions as to render violent exertion possible without distress. I believe that considerable progress is possible along these lines, and that, by the addition of an arrangement for humidification, it might be possible to stop even the finest dust. At best, however, I believe that the field of respirators is limited.

The use of dust-collecting bags is reported in three instances, which were unsuccessful, because all appliances so far produced have been a nuisance. The failure of water sprays is shown by the fact that, though reported in 29 instances, only one successful result is claimed—in connection with drifting, where the dripping of the water on the operator is naturally not as extensive as in overhand stoping and raising. Waterfeed hand drills—unmounted machines of the Jackhamer type—are extensively used. In drifting, four instances are given, three of which were successful; the other case was unsuccessful, because, as stated, the men prefer inhaling dust to getting wet, and because of mechanical imperfections in the machine. In underhand stoping, three instances are given, all successful, although objection was recorded in one instance on the ground that the safety precaution involved too much inconvenience. For sinking, nine instances are given, eight of which were successful. In the one unsuccessful instance the objections were that the steel sticks, that the machine cannot be rotated by hand, and that no dust is produced by dry sinking, anyhow. Evidently, because my questionnaire was not well worded, I failed to elicit any information either for this type of drill, or for others used in block holing. This I regret, because, in many mines, block holing undoubtedly contributes materially to the dust in circulation, as it is carried all over the stopes and often into the chutes, during shift; and, indirectly, because boulders are frequently blasted during the shift, with the consequent spreading of dust.

EXPERIENCE WITH DRILLS

The water-feed stoping drill is a machine of comparatively recent development. Mechanically it leaves more to be desired than any of the other modern hammer drills. It has great inherent possibilities; and to many operators it has seemed that designers and manufacturers have not fully recognized the extent of these possibilities, and have not given the question of the development of this type of machine the attention which it deserves.

In drifting, five instances are shown, of which four were successful. In overhand stoping, which would appear to be an ideal field for this machine, five instances are recorded, three unsuccessful, resulting in the comment that the men prefer dust to getting wet. Workers will not employ a safety device which causes discomfort or inconvenience, and no one should expect them to do so.

In raising, in 11 instances of the use of this type of machine three were successful. One of the successful cases is qualified by the familiar objection that the men prefer dust to getting wet, and that the machine has not been perfected mechanically; another comment was that the men will use the wet stoper if the wages paid are high enough, even if they do get wet. Of the eight unsuccessful instances, six were based on the grounds that the men prefer the dust to the water; another agrees to this and mentions the disadvantage of high maintenance cost; and still another supplements the same objection by referring to the frequency of the steel sticking, making rotation by hand impossible.

Two operators report the use of dry drills with auger steel for drifting or undercutting in soft ground. This type of equipment is recommended for these conditions by three operators, as being substantially dustless; and it is possible that this combination has not received the attention that it deserves, although it can be employed only under favorable conditions.

That the water-feed mounted drill is now the standard machine in most mines is clearly indicated in the table. In drifting, 22 instances,

all successful, are shown, although in the case of one of these the machine is used in wet ground, and dust allaying is not considered one of its functions. In overhand stoping, of 11 instances nine were successful and two unsuccessful, the latter being due to mechanical imperfections and the fact that the men prefer dust to water. In underhand stoping, eight applications, all successful, are shown. In raising, nine instances are given, of which seven were successful, although one is qualified as partly successful, and one refers to use of the machine only if the ground is dry, but says that "the men prefer the dust to getting wet." In the two instances of failure this same familiar reason is given. In sinking, 12 instances, all successful, are quoted, one operator saying that the machines are used occasionally, but are not usually necessary; and another, that the water feature is not employed to allay dust.

USE OF THE WATER-FEED MOUNTED DRILL

To the man interested in safety alone, an examination of the accompanying tabulation would lead to one conclusion—that the water-feed mounted drill should be employed universally for drifting, overhand and underhand stoping, raising and sinking. Fortunately in some mines—instances of which are shown in the table—the dictates of mining economics appear to agree with those of safety. The water-feed mounted drill has been adopted for all purposes, and it is reported throughout as a successful machine. To what extent this conclusion represents the results of actual comparison I am, of course, not informed, but my own experience leads me to believe that in overhand stoping and raising, particularly in the latter, a properly designed water-feed self-rotating stoper would insure faster and cheaper progress than could be obtained with any mounted drill. In many overhand stopes the same would be true; and, even in drifting, the water-feed hand-rotated stoper is a much more formidable competitor, as compared with the mounted water-feed drill, than is generally supposed. There is reason to hope that, with the development of the former, much more effective work may be done in drifting than is now possible. It is these considerations which suggest that the manufacturers of rock drills should devote more attention to the development of this machine.

Some of the drills now available are convenient, light and extremely powerful, but their maintenance cost is high, and they contain details of design borrowed from machines intended for other purposes, which, under new conditions, cause difficulty and delay. In overhand stoping and raising, about the only advantage discernible, from the point of view of the operator, in the use of the mounted water-feed drill, as against the stope, is that the mounted machine is self-rotating, and it is not necessary for the operator to stand so close to the drill barrel; therefore, he does not get so wet as with the other machine. The operator of the hand-rotated water-feed stoper, owing to the necessity for hand rotation, has to stand close up, where he receives all the drip and spatter. With an automatically rotated stoper, this proximity to the machine would not be necessary.

IMPROVEMENTS IN DRILLS

So far as mechanical troubles which result from water and drill sludge running down the steel and into the working parts of the machine are concerned, there is no apparent reason why the same improvements in construction would not eliminate these difficulties also. That this is the thought of other operators is evidenced by the response to the request for suggestions for improvements. Three of these refer to the development of a perfected self-rotating water-feed stoper, and one refers to means for the reduction in the indiscriminate use of water in the machines engaged in overhand stoping and raising. A certain amount of water is required to allay the dust effectively. In many cases the design of the machine is such that much more water is discharged through the steel than is necessary, or water is released at other points, with the result that the operator is constantly sprayed, and the machine is condemned.

SUCTION VENTILATION IMPRACTICABLE

Ventilation by suction from the working faces would prevent the distribution of any quantity of dust through the mine atmosphere; but would be more expensive and difficult to apply. The problem of the ventilation of metal mines, comparatively speaking, is in its infancy; and many projects which might now be condemned as impracticable or too expensive will later become customary, as advanced practice or legislation suggests their adoption.

MACHINE MUST BE AS NEARLLY AS POSSIBLE "FOOL PROOF"

At present, conditions, rather than theories, must be faced. Mines must be made safe, regardless of whether the motive for doing so is lofty, or simply that of making a virtue of necessity. Few metal mines would show an atmosphere conforming, for example, to the South African regulations; and, as it is idle to talk longer of disciplining labor or of making the men do this or do that, it is obvious that the only solution possible is the use of drilling apparatus which will be inherently non-dust producing, and at the same time not be objected to by the men. In order to combine with these qualifications a drilling rate which will make it possible for the mine to operate, the machine must operate successfully, must be light, simple, durable, powerful, and, at the same time, as nearly as may be, "fool proof."

BURNING PULVERIZED COAL

By W. G. Wilcox*

The simplest view of the combustion of coal is to regard it as a reaction between fuel and oxygen. It is a heterogeneous system; consequently the velocity of the reaction and its completeness will depend upon the surface exposed by the solid, the pressure of the reacting gas, and the intimacy of the mixture. By grinding an inch cube of coal so fine that 85 per cent. will pass a 200-mesh screen, we have increased the surface exposure from six square inches to approximately 1,800 sq. in. Thus we have increased the velocity of combustion 300-fold. By doing so, we have changed the characteristics of the fuel. We now have a fuel relatively 300 times more active than the inch cube of coal, a new type of fuel that has in it inherent possibilities not to be found in lump or slack fuel. By increasing the surface of exposure 300-fold, we have speeded combustion proportionately. This carries with it a further effect. The increase in rapidity of combustion also increases the rapidity of heat evolution, and consequently quickly raises the temperature of the rest of the material. This rise of temperature, which is much more rapid than in the normal combustion of coal, will double the velocity of combustion for each rise of 10°C. The increased rapidity due to greater surface exposure and that due to temperature rise are superimposed, so that a pulverized fuel affords a combustion that is hundreds of times faster than when burning lump-coal.

*From a paper before New York Section American Chemical Society.

ADVANTAGE OF MIXING COAL AND AIR

Having a finely-divided fuel it is possible to form a mixture of fuel and air so intimate that each small particle of coal is surrounded by the proper amount of air. In this condition, by maintaining the proper velocity of the air-current, the fuel can be carried into the furnace in suspension and there burned completely, efficiently, and rapidly.

It is, of course, a simple matter to mechanically control the amount of powdered coal delivered to the furnace in a given time. It is also possible to control the amount of air delivered with the coal. If, then, we deliver to the furnace an intimate mixture of air and powdered coal, and control the amount of coal-dust and air delivered, we have the prime essentials. The degree to which they are attained depends entirely upon how carefully we study the charaeteristics of the fuel before and during combustion.

The amount of coal-dust delivered can be controlled simply and positively by using a screw-feeder operated at variable speed. It is also a simple matter to control the volume of air admitted with the fuel; but the highest efficiency possible with this type of fuel will not be obtained unless we work out a correct way in which to mix a finely divided solid with the air.

INCORRECT MIXING METHODS

A study of the methods for making such a mixture immediately shows that the methods commonly used in making a uniform mixture of two miscible liquids or a uniform solution of a solid in a liquid, or the methods used in mixing finely-ground solids are not only useless in this case, but will actually separate the coal-dust from the air. Ordinary mixing is done by agitation; this agitation is usually accomplished by baffling, stirring, shaking, or similar devices. When, however, such methods are applied to a mixture of gas and finely divided solid, the solid tends to separate by

reason of its higher specific gravity. This, in fact, is the principle of the well-known cyclone dust-collector. Any mixing device that produces such agitation of the dust and air as to give a centrifugal effect will tend to separate, not mix, the air and the dust.

The importance of mixing the coal-dust and air intimately cannot be exaggerated. The rapidity of combustion is a direct measure of the intimacy of the mixture. This is well illustrated by comparing the ordinary gas-flame with the flame obtained in the Bone combustion system, which consists in forcing the proper proportion of air and gas through a diaphragm having numerous interstices. When this mixture is ignited on the other side of the diaphragm, it produces a film of flame.

The poorer the mixing, the longer the flame. The flame simply outlines the area in which combustion is taking place and the length of the flame is a measure of the time element necessary to accomplish combustion. This time element—other conditions being equal—is absolutely a function of the intimacy of mixture, as was noted by Breckenridge 10 years ago, when in Bulletin No. 325 of the United States Geological Survey, he stated:

"The conclusion is reached that the velocity of combustion decreases enormously from the surface of the fire to the rear of the combustion-chamber, where it is relatively very small, the practical application is that little is to be gained by adding further length of smooth combustion-chamber, which would be commercially as poor an investment of capital, as to add to the length of a Corliss engine-cylinder and stroke; we must resort to thorough mixing."

Just as in the past there has been a remarkable failure to realize the necessity for intimately mixing air and coal-dust, so there has been insufficient consideration of the characteristics of this fuel when burning. Powdered coal has the characteristics of a rich fuel of somewhat higher kindling temperature than producer-gas, natural gas, or fuel-oil.

VELOCITY AND PRESSURE

The rapidity of combustion and the completeness of combustion of a mixture of coal-dust and air depend upon a number of factors: for example, they are dependent upon the velocity and pressure at which it is passed into the combustion-chamber. If the velocity of the incoming stream of powdered coal and air is above the velocity of flame propagation combustion will not take place until the mixture has slowed down to a point that it does not exceed the velocity of flame propagation. When a powdered coal is fired at high pressure and high velocity, combustion frequently does not begin until a point four to six feet from the mouth of the burner. A similar example is found in the plumber's blow-torch when too much air is used, or in the Bunsen burner when the gas-pressure is too high. High-pressure firing not only slows down combustion, thus increasing the size of the chamber necessary, but has a destructive action on the furnace. It has been well established that high velocities in the combustion-chamber or a blow-torch effect due to firing at high pressure (whether oil or gas be used as a fuel) are always destructive of the brickwork. This action is increased in high-pressure firing of powdered coal, since, in addition to the erosional effect of gases at high temperature traveling at high velocity, there is a fluxing action by the melted ash. Furthermore, the slagged ash will be carried along mechanically, leading to further furnace troubles. In one case this resulted in a deposit of slag on the muddrum of a vertical waste-heat boiler at the end of a long reverberatory furnace. Slowing the velocity not only hastens combustion, but makes it possible to eliminate much of the slag. When the velocity is low the coalesced particles of slagged ash are either larger than will be carried by the velocity of the gas or this condition is so nearly approached that a slight change in direction of the flame will result in dropping out the slag. Thus, in addition to being correct combustion and necessary in order to avoid excessive furnace-maintenance costs, low-velocity combustion, by a slight change in flame direction, permits the dropping out of a large quantity of the slagged ash in the early part of combustion, where it can be removed and will not interfere seriously with efficient metallurgical operations.

The velocity of combustion is not only dependent upon the fineness of the particles of coal, the intimacy of the mixture, and the velocity of the stream of combustible and air, but is affected by the temperature of the combustion-chamber. The kindling temperature of a mixture of powdered coal and air is higher than that of either oil or gas; consequently

for successful and complete combustion, it is necessary that the combustion-chamber be maintained above a certain minimum temperature and that the combustion be practically completed before the products of combustion pass over the heat-absorbing surface. Just as you can extinguish a gas flame by passing over it a piece of wire-gauze, so the effect of a chilling surface will be even more marked with this combustible material than with burning gas, since the particle of coal is infinitely larger than a molecule of gas and the kindling temperature is also higher. This has a direct application to the successful firing of locomotive boilers, water-tube boilers, and return-tubular boilers. If the combustion of powdered coal be not sufficiently developed before the flame enters the tubes of the locomotive boiler, combustion will be checked and coked coal settle out in the tubes. If, on the other hand, combustion be sufficiently developed before the flame is brought in contact with the heat-absorbing surface, complete combustion and high efficiency are obtained.

A study of the flame developed at a low pressure by an intimate mixture of coal-dust and air shows that combustion is extremely rapid. In a copper-reverberatory furnace at Florence, Colorado, where this type of combustion is used, coal burned at the rate of approximately one ton an hour develops a flame that vanishes within six feet of the burner, combustion being complete at that point. Let us translate this into terms of natural gas, in which case the fuel consumption would be approximately 26,000 cu. ft. per hour or 433 cu. ft. per minute. You can picture to yourself this quantity of gas being burned at low pressure and developing a flame only six feet long. Samples of gas taken in the flame show a content of CO_2 as high as 16 per cent only five feet from the mouth of the burner. This will give an example of the rapidity with which combustion can be obtained and the possibilities of shortening the flame. With proper equipment it is equally practicable to lengthen the flame until it will spindle out a distance as great as 100 or 120 ft. However, with an intimate mixture under control, this must be done by supplying insufficient air. Under such conditions combustion is incomplete and the flame spindles out because combustion continues to develop throughout the length of the furnace as air-leakage supplies additional oxygen. This is proof of the statement that the length of flame is an actual measure of efficiency of mixing and the adjustment of the fuel-air ratio.

ADVANTAGES OF POWDERED COAL

Thus, it is seen that we have changed entirely the characteristics of coal as commonly known. Powdered coal is a fuel of extreme flexibility, in that the amount burned can be varied within wide limits. It is a fuel that develops a flame whose length can be adjusted. The character of the flame can be altered to suit the metallurgical operation. In short, the basic fuel, coal, has acquired the characteristics of oil or gas, but with better and closer control. Furthermore, the possibilities of this fuel are not only capable of realization, but are actually being utilized in commercial practice today. To the flame characteristics of a rich fuel, developing a flame like oil or gas, is added a degree of control not yet obtainable in burning either oil or gas. This statement is made advisedly. The possibilities of such combustion for the improvement of processes, for fuel economy, for increasing output, through its ease of control and elimination of heavy labor, are realized by few. Owing to the attitude of labor and the scarcity of skilled operatives, it is far more difficult than ever before to secure high efficiency and good operation in hand-firing, stoker-firing, or in producers, in short, whenever such efficiency depends upon constant watchfulness and hot, heavy, disagreeable work. For these conditions powdered coal substitutes an ease of control so simple that a man of ordinary intelligence can soon be taught all that is necessary for good efficiency in operation, or it can be handled by an old man or boy. The possibilities of such control in the place of present-day combustion methods, which permit high efficiency only by the most strenuous effort, through substituting for these a type of combustion whereby high efficiency is easily obtained, are certainly of great importance to us at the present time.

NOTES

Bottoms of Mine Cars may be cleaned by means of a drill of the jack-hamer type, fitted with a flat or wedge-shaped bit. The operator manipulates the machine with a short "sceoping" motion to loosen the material, which is afterward removed with a short-handled shovel.

Now that the war is over, we should have an exhibition of the freak inventions offered to the Government. If to this could be added the really useful inventions, which were accepted and proved of value, it would be a most enlightening source of education.

Compressed air from a compressor should not be used for cleaning relays when blowing out the switchboard. Air may be blown into the relays, making them inoperative. A bellows answers the purpose for cleaning the relays.—*Electrical Review.*

Fuel oil and crude oil are not the same, even though they are often used interchangeably. Fuel oil is the residue left after certain of the lighter constituents of crude oil have been removed by partial distillation. Thus, fuel oil has a greater specific gravity than the crude oil from which it is obtained.

A writer in *The Scientific American* states that common salt is an efficient decarbonizer. First get the engine warm and in easy starting condition. Then remove the spark plugs and pour a teaspoonful of common salt into each cylinder. Replace the plugs and start the engine and "the carbon will pour from the exhaust."

Claiming that the Oliver Iron Mining Company for ten years has been using an ore washer on the basic principles of which he holds the patent, Captain Alexander McDougall, an inventor and president of the McDougall-Duluth Shipbuilding Company has brought suit for $40,000,000 against the mining company.

The chairmen of 88 draft boards, after conferences with representatives of the Illinois Manufacturers' Association and the Association of Commerce, authorize the statement that there will be jobs waiting for the 175,000 soldiers and sailors who entered the service from Chicago when they return. Those who do not receive their former positions will be promoted to better ones, it is said. The men will be provided with transportation to Chicago after they are mustered out.

Military planes flying above an altitude of 10,000 ft. are equipped with an apparatus for supplying oxygen to the flyers. It was proved by the English air casualties that 90 per cent. of the accidents was due to the flyers suffering from lack of oxygen. The device was designed by Lieutenant Colonel Dryer of the British R. A. M. C., and works under variable tank pressure from 100 to 2250 lb. per square inch with a temperature range of from 70 deg. to 80 deg. F. to 20 deg. or 30 deg. below zero.

The world's largest producing oil well, which in the last eight years has been known to maintain an average production of 50,000 barrels per day, totaling more than 100,000,000 barrels during the time of its existence, suddenly started spouting salt water. Although there is still a large percentage of crude flowing from the well, nevertheless it is believed this marks the beginning of the end. The well is the Mexican Eagle Oil Company's Potrero No. 4, in the Tampico district, Mexico.

Two French chemists, Francis Labriel and Raoul Oesgorge have invented a process, it is stated, whereby milk can be converted into a fabric which may be used for clothing and ornaments. By means of chemical treatment, curds resulting from this process can be reduced to a plastic substances which may be rolled into sheets resembling celluloid. This product can then be made so soft that it may be used as a substitute for silk in the manufacture of fine underwear or in its solid state can be converted into buttons, etc.

A non-inflammable gas, officially termed "argon," for the use of balloons and dirigibles has been discovered, which will eliminate the hazard of fire and explosion that always has accompanied balloon operations where hydrogen gases have been used. The gas from which argon is obtained comes from wells at Petrolia, Tex., owned by the Lone Star Gas Co. A pipe 94 miles long is proposed to be laid from the wells to a plant at North Fort Worth, where the gas will be compressed into cylinders for shipment to the balloon fields.

The highest temperature ever recorded by the U. S. Weather Bureau shows a maximum of 134° F. established at the Greenland ranch in Death valley during the month of July, 1913.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

NOVEMBER 5.

1,283,472. APPARATUS FOR LIQUEFYING AIR AND SEPARATING IT INTO ITS CONSTITUENTS. Charles F. Crommett, Chelsea, Mass.

1. In an apparatus of the character stated, means for compressing and cooling air, means whereby the compressed air is divided into three portions, means whereby one of said portions is caused to liquefy the second portion, and means whereby the third portion is caused to evaporate the liquid produced from the second portion of said compressed air.

1,283,502. GAS-PRESSURE REGULATOR. Jacob C. Groble, Anderson, Ind.

1,283,524. VACUUM FUEL-FEED DEVICE FOR AERIAL-VESSEL ENGINES. Webb Jay, Chicago, Ill.

1,283,529. FAN-PUMP. Henry Kleckler, Buffalo, N. Y.

1,283,565. ELECTRIC VACUUM - CLEANER. George T. Robinson, Bowling Green, Ky.

1,283,593. METHOD OF AND APPARATUS FOR COMPRESSING FLUID. Robert Suczek, Philadelphia, Pa.

1. The method of compressing elastic fluid, which consists in partially compressing the same by ejector action in each of two stages, and in the first stage entraining and compressing said elastic fluid by elastic motive fluid of such quantity as to cause in the first stage a ratio of compression not less than the ratio of compression in the second stage.

1,283,644. COMBINATION VACUUM CLEANER AND SWEEPER. Charles A. Boyer, Warsaw, Ind.

1,283,769. ATMOSPHERICALLY - RESPONSIVE DEVICE. Nels Hofstad, Chicago, Ill.

1,283,823. APPARATUS FOR GASIFYING LIQUID GASES. Fortunato Levy, Paris, France.

1,283,981. ELECTROPNEUMATIC BRAKE. Walter V. Turner, Wilkinsburg, Pa.

1,284,000. AIR-VALVE FOR FLUID-PRESSURE BRAKE SYSTEMS. Frank H. Weimer, Nogales, Ariz.

1,284,033. LIQUID-FUEL BURNER. Clarence H. Allison, Chicago, Ill.

1,284,053. SMOKE-CONSUMER. William L. Briggs, Gadsden, Ala.

1,284,147. CONTROLLING MEANS FOR PNEUMATIC APPARATUS. Guy M. Russell, Rochester, N. Y.

NOVEMBER 12.

1,284,220. LIFE-BELT. Paul Bergen, Richwood, Wis.

1. In a life-saving appliance of the class described, a box-like generator having a gas chamber, material in said chamber adapted, when subjected to water, to generate gas, a water chamber, and a valve normally open and subject to gas pressure in the gas chamber to cut off communication between the water chamber and gas chamber.

1,284,225. FLUID-OPERATED DEVICE. Fred H. Bogart, Philadelphia, Pa.

1,284,336. SYSTEM OF DISTRIBUTION FOR HUMIDIFYING, HEATING, AND AIR-CONDITIONING APPARATUS. William B. Hodge, Charlotte, N. C.

1,284,361. CRUDE-OIL BURNER. Bernerd W. Kelly, Somerset, Ky.

1,284,530. PNEUMATIC SUPPORT FOR VEHICLES. William G. Wood, Sacramento, Cal.

1,284,594. LIQUID-ELEVATING APPARATUS. Edward Christman, Massillon, Ohio.

1,284,614. PNEUMATIC ENGINE-STARTER. John E. Desmond, Detroit, Mich.

1,284,662. CENTRIFUGAL PUMP AND COMPRESSOR. Reginald F. Halliwell, Rugby, England.

1,284,705. AIR-DRAFT MOTOR. Charles Kappel, Chicago, Ill.

1,284,926. ATOMIZING METHOD FOR MAKING FORMS AND CONTAINERS FROM FIBROUS COHESIVE SUBSTANCES. John P. Raymond, San Francisco, Cal.

1. The method of making fibrous forms and containers consisting of the steps, first, agitating a mixture of fibrous pulp and water, second, atomizing a column of said mixture, and, third, in conducting into a porous mold by the action of air pressure said atomized mixture for the purpose of forming a contiguous layer of pulp of any desired shape and thickness free from moisture.

NOVEMBER 19.

1,284,964. REFRIGERATING APPARATUS. August P. Anderson, Chicago, Ill.

1,285,101. PERFUME-DISPENSER. Freling C. Foster, Jr., Chicago, Ill.

1,285,302. MOLDING-MACHINE. Charles P. Melvin, Youngstown, Ohio.

1,285,391. PNEUMATIC MATTRESS. Charles B. Robertson, Columbus, Ohio.

1,285,396. PNEUMATIC ACTION OF PIPE-ORGANS. Charles F. Rowe, Chicago, Ill.

1,285,415. VACUUM-COOLER WITH INTERIOR ABSORPTION. Paul Schou, Copenhagen, Denmark.

1,285,417. MACHINE FOR MAKING MOLDS. Theodore C. Schultze, Grand Rapids, Mich.

1,285,420. BOTTLE - BLOWING MACHINE. James P. Scull, Millville, N. J.

1,285,484. LOCOMOTIVE-BLOWER. Axel S. Vogt, Altoona, Pa.

1,285,487. DRAFT-ACCELERATOR AND VENTILATOR. John J. Wagner, Green Cove Springs, Fla.

1,285,552. PROCESS OF EXHAUSTING AIR FROM THE PRESENCE OF FOOD PRODUCTS. Arthur Barry, Liverpool, England.

1,285,557. AIR-GAGE INDICATOR. Edgar Boyd Camp, Anaheim, Cal.

NOVEMBER 26.

1,285,586. TORPEDO-LAUNCHING APPARATUS. Frank Baker, Broadview, Saskatchewan, Canada.

1,285,618. PNEUMATIC WHEEL. James A. Carter, St. Louis, Mo.

1,285,649. AIR-BRAKE-CONTROL SYSTEM. Frank H. Dukesmith, Meadville, Pa.

1,285,808. COMPENSATING AIR-PUMP FOR PNEUMATIC VEHICLE-WHEELS. Harry C. Schroeder, Berkeley, Cal.

1,285,824. PREPARATION OF METAL NITRATES. Walter O. Snelling, Long Island City, N. Y.

1. The process that comprises treating a sulfid-containing liquid, under sub-atmospheric pressure, with an acid capable of reduction by hydrogen sulfid.

1,285,952. LIQUID-FUEL BURNER. Dudley de Ros, Islington, England.

1,285,968. VENTILATOR UNIT. Frederic A. Finegan, Flushing, N. Y.

1,285,975. PNEUMATIC ACTION. Robert A. Gally, Cincinnati, Ohio.

1,286,052. MILKING-MACHINE. Benjamin J. Miller, St. Paul, Minn.

1,286,099. VACUUM-CLEANER. Frank B. Rae, Cleveland, Ohio.

1,286,115. SUCTION-CLEANER. William W. Rosenfield, New York, N. Y.

1,286,119. AIR-PRESSURE GAGE. George A. Sagaser, Hanford, Cal.